Transnational Journal of Mathematical Analysis and Applications
Vol. 2, Issue 2, 2014, Pages 131-155
ISSN 2347-9086
Published Online on January 28, 2015

http://jyotiacademicpress.net

APPLICATION OF AVAILABLE TECHNOLOGIES FOR DEVELOPMENT, CONSTRUCTION AND OPERATION OF SOLAR PLANTS WITH CONCENTRATORS

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Abstract

The best available techniques (BATs) are used now widely in the different industries. The paper contains the description of some new technologies, or BATs, intended for the concentrating solar plants (CSPs) and installations. The most part of these BATs presented in article were suggested in ENIN. But together with them, there are some foreign prospective technologies or BATs. Some BATs were suggested both in ENIN and abroad, and they include the hybrid plants, the usage of thermal accumulators and the application of effective high-temperature heat carriers. The differences between different approaches in Russia and abroad are shown. All of them have a goal to increase the CSP efficiency. Some BATs were developed a certain time ago, but some were developed during the operation of existing large and small CSP. The niche of using different plants determines the placement and sphere of applications of these small and large plants with concentrators. A progress in creating the tower CSPs as well as the installations with parabolic troughs (PT) and Fresnel lens is

2010 Mathematics Subject Classification: 34-xx, 70-xx, 76-xx, 80-xx.
Keywords and phrases: best available techniques, concentrating solar plant, hybrid plant, thermal accumulator, high-temperature heat carrier, large and small solar plants, tower solar plant, parabolic-trough solar plant, thermo-photovoltaic plant.
Received December 3, 2014

shown. The one-loop and two-loop CSPs are compared, and the advantages and problems of one-loop plants are shown. The recommendations for future works and investigations are given and they include not only BATs but also the solution of such problems and indicators as financial support, economic indices, education and even safety measures.

1. State and Modern Level of Concentrating Solar Plants Development in the World

The intensive development of concentrating solar plants (CSPs) is currently taking place in the world. The plants include the tower and parabolic trough CSPs and the CSPs with Fresnel lens. As a rule, the development of methods for increasing the efficiency of corresponding plants is carried out at the small experimental benches imitating the large plants at the place of their future layout (Zarha and Muizhead [1]). The operation of installations and their elements was studied both at the laboratory-scale plants of ENIN and at the small solar water-lifting plants with PT in Crimea (at the territory of SPP-5), in Makhachkala (Dagestan), Bukhara, Yangi-Yul and Fergana (Uzbekistan) [2].

The plants in Bukhara and Fergana are shown correspondingly in Figures 1 and 2.

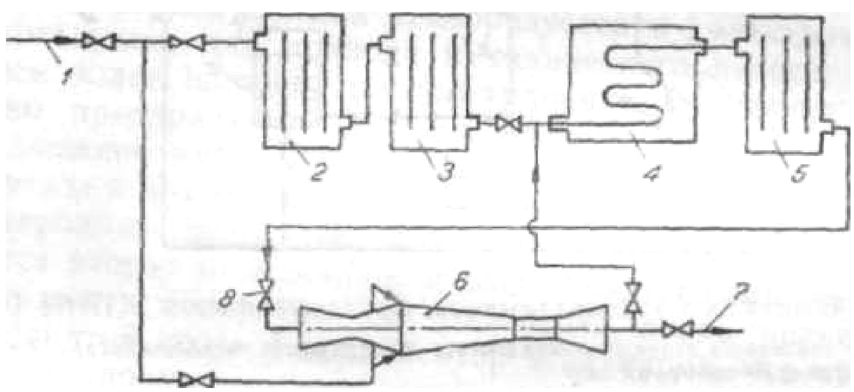

Figure 1. Schematic diagram of solar water lifting plant with flat heaters and jet pump in Bukhara: (1) water pipeline; (2), (3) and (5) solar collectors of Bukhara works for heliodevices; (4) solar heater of pipe type; (2) and (3) with single glazing; (5) with double glazing; (6) laboratory jet pump-injector; (7) to consumer; and (8) valve for startup.

The jet pump for the plant in Bukhara was designed for lifting 10t/h of water, while the collector could provide the lifting of water volume by injector only no more than 0.5t/h. Therefore, the plant could operate with the intermittent duty with the vapour accumulation in heaters. Injector (or jet pump -JP) was designed after the tests in Fergana for the less flow rate. It was manufactured and operating at the plant in Fergana, and it was subject as well to the different tests.

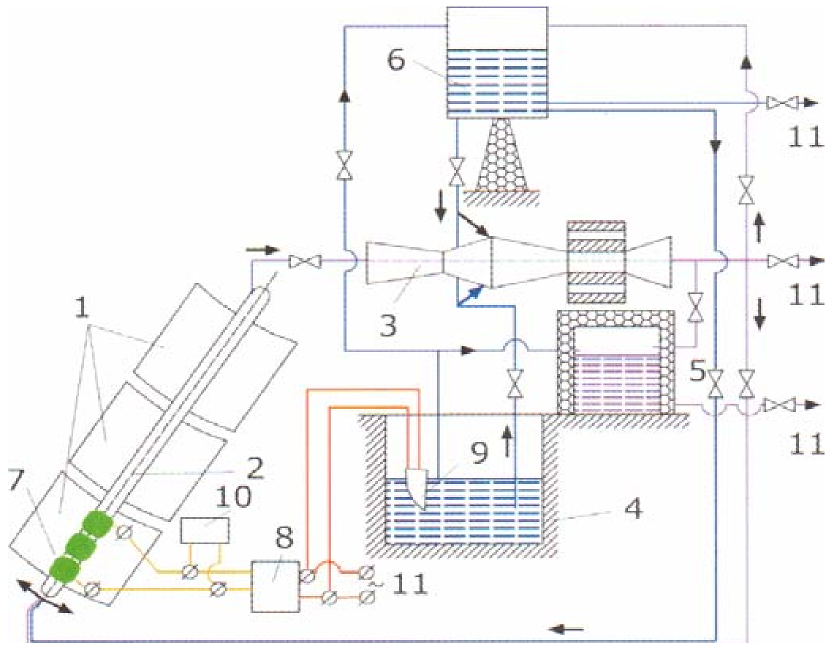

Figure 2. Diagram of solar plant with PT: (1) parabolic trough; (2) heat collecting element; (3) jet pump; (4) well; (5) and (6) collecting tanks; (7) photovoltaic array; (8) inverter; (9) submerged pump; (10) accumulator battery; and (11) power and water supply to customer.

Both the plant and its separate elements including PT were tested. The similar PTs was installed at other three above mentioned plants. As it follows from Figure 2, the storage tanks for hot (5) and cold (6) water in Fergana allowed organizing the water supply of consumer. In the periods of insufficient solar radiation, it was possible to obtain the steam when it was necessary. The water from tank (6) was also used for JP startup, while the heated water from the tank (5) allowed using it as economizer in the loop, containing the PT heat receiver and the JP.

The results and recommendations obtained in Fergana could be used in other solar plants with PT and in the geothermal units for water lifting, heat supply, and power production. The schematic diagrams of CSP were developed after it in ENIN and were protected by patents. The storage tanks for the cold and hot heat carrier are also used in the modern foreign tower and PT CSP. The melt of Na and K salts is used in them as the high-temperature heat carrier and it is one from the most important BATs today allowing to prolong the time of servicing the consumer under insufficient solar radiation or its absence (Kabakov and Yeroshenko [7]).

2. Small CSP of ENIN and Problems Solved at them

The investigations carried out in ENIN laboratories and under field conditions allowed first of all to develop the methods of analysis of main elements and to solve successfully many operating problems that resulted in obtaining some important BATs. We are mentioning only some these engineering solutions that became BATs. One of them concerns the new PT construction shown in Figure 3 and allowing to carry out the adjustment of optical system by means of ropes, tension bracings, and bolts (Kabakov et al. [3]).

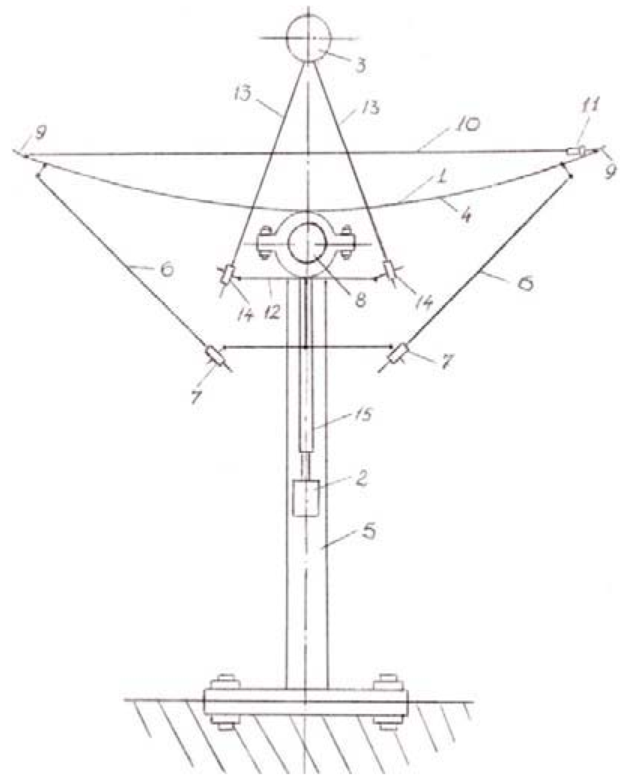

Figure 3. Diagram of CSP PT with adjusting optical system**:** (1) reflector; (2) counterbalance; (3) solar receiver (SR); (4) reflector substrate; (5) base of substrate; (6) tension bracing; (7), (11), (14) adjusting bolts; (8) side-member; (9) circumferential sections of substrate; (10) ropes; (12) bracket; (13) tension bracings; and (15) telescope joint.

Another problem was the determination of optimal placement and cooling of PV modules at SR (Kabakov and Levin [4]; Annaberdiev and Baum [5]; Kabakov et al. [6]).

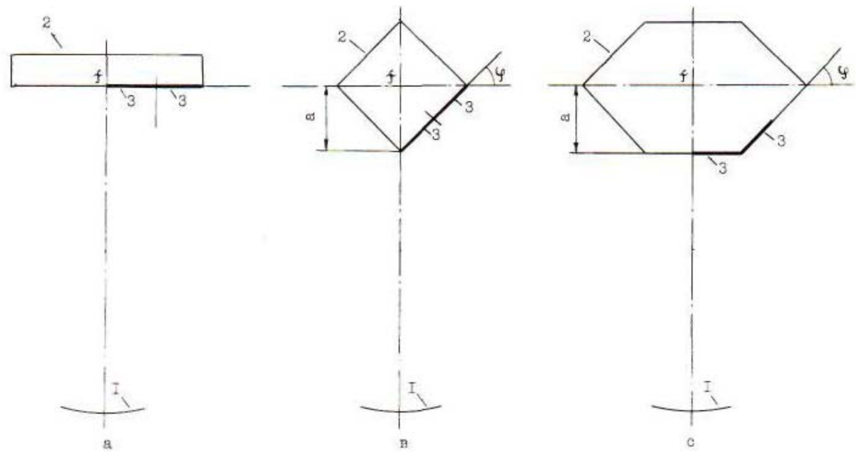

Figure 4. Orientation solar receiver channel for the different locations of PVC relatively reflecting surface of PT: (a) slit channel; (b) square channel, $\varphi = 45^o$; (c) profiled channel, $\varphi = 45^o$ [(1) reflecting surface of PT, (2) channel wall, (3) PVC with size 0.02m, (f) focus of reflecting surface of PT, (a) distance between PVC and focus, φ-angle of slope of PVC surface relatively aperture].

The calculations showed that the trapezoidal form of SP (the right SP in Figure 4) is optimal for obtaining the most uniform form of light reflected from PT for PVC located on SP.

Taking into account the results of experimental investigations, the nomograms were obtained for determining the water temperatures at inlet and outlet of photothermal receiver with the different values of PVC temperature and the density of heat flux at the walls of channel (Figure 5).

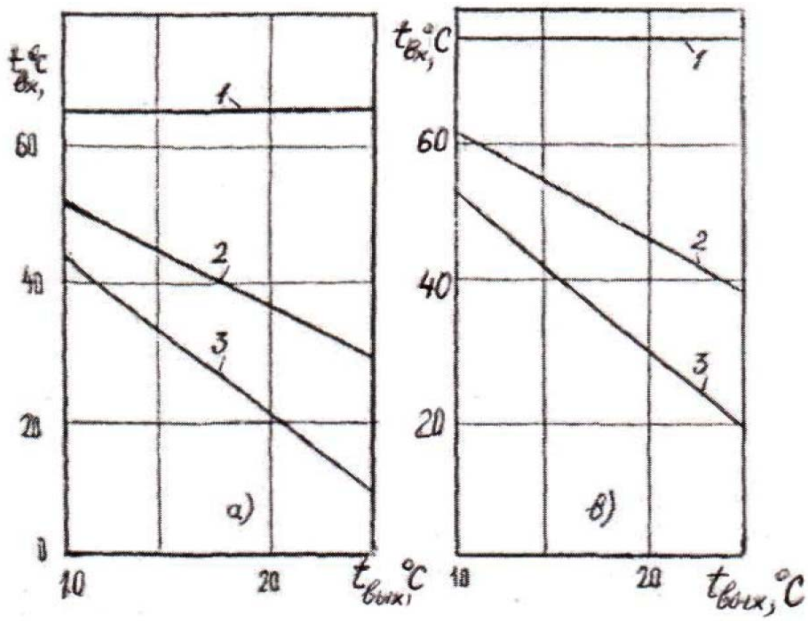

Figure 5. Nomograms for determining the water temperatures at the inlet and outlet from photothermal receiver (square channel, heat supply to two sides, water flow rate 0.75kg/s); (1) t_{PVC} lim; (2) t_{outlet} lim; and (3) t_{inlet} lim; (a – 65°C; b – 75°C).

The liquid injection through the holes in jet pump (JP was suggested and studied by author) as well as the multi-jet injection in vacuum solar receiver (SR) (suggested by Schwartz solar heat exchanger, US Patent no. 4372291, Feb. 1983) was investigated for optimizing the heat transfer under phase transformations (correspondingly with condensation and boiling) in these elements and for improvement of their characteristics (Kabakov [9]; Kabakov [10]).

The constructions of JP and SR with multi-jet liquid injection are shown correspondingly in Figures 6 and 7.

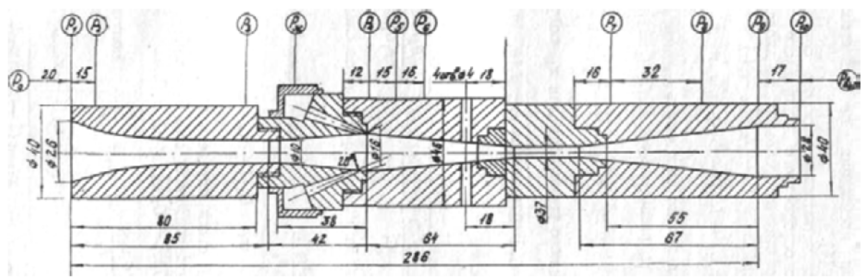

Figure 6. Condensing injector (JP) with multi-spray injection of liquid.

The effect of heat- and mass transfer of spreading and break-up of liquid jet with the consequent taking place of the processes of condensation or boiling have been studied. It was shown how it effects on operating and geometric parameters of pointed elements.

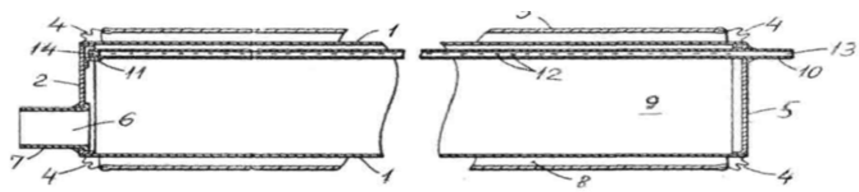

Figure 7. Solar receiver (SR) with supplying liquid through holes: (1) tube of SR; (2) end wall; (3) glass pipe limiting vacuum space; (4) bellows seal; (5) front wall; (6) steam discharge; (7) pipe of steam discharge; (8) annular vacuum space; (9) inside chamber of SR; (10) pipe of liquid inlet; (11) support for fastening of pipe (10); (12) holes for supply and spraying of water jets; (13) inlet in water supply pipe; and (14) closed butt of pipe (10).

2.1. Suggested diagrams of CSP suggested in ENIN

The results of corresponding investigations mentioned briefly above were used for developing and designing the solar plants (Kabakov [11]).

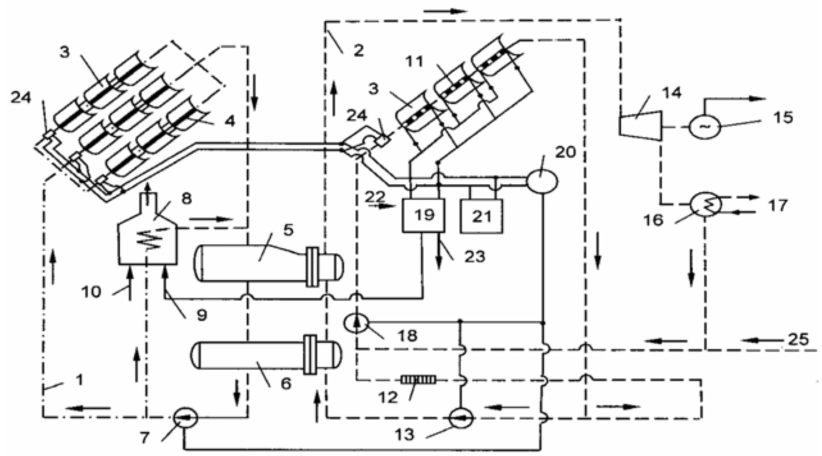

Figure 8. Hybrid thermophotovoltaic two-loop CSP of ENIN: (1) first loop with heat carrier; (2) second steam-water and steam-turbine loop; (3) modular PT concentrators; (4) solar receivers; (5) steam superheater; (6) steam generator; (7) circulating pump in the first loop; (8) boiler; (9) hydrogen inlet; (10) natural gas inlet; (11) SR of modular PTC (3) with PVC installed at them; (12) heat supply system; (13) circulating pump in the second loop; (14) steam turbine; (15) generator; (16) condenser; (17) inlet and outlet of cooling water; (18) circulating pump; (19) electrolyzer; (20) inverter; (21) storage cell; (22) inlet of liquid heated in SR; (23) oxygen outlet from electrolyzer; (24) drives of sun tracking system on PTC; and (25) replenishment of heat carrier loss in the second loop.

The joint usage of thermodynamic and photovoltaic methods of energy conversion [8] was protected by a few ENIN patents. One from the corresponding schemes is shown in Figure 8. It has two loops and two PTC fields. PVCs are located at SR of the second field, while SR fulfills itself the role of economizer in the second loop. The scheme has two apparatus: steam generator and super heater. The scheme presented further in Figure 11 reminds to a large extent the scheme at Figure 8, which was patented in 1982, whole the American scheme is perfectly new one currently constructed. Their difference consists of the fact that our scheme is with PTC, while the American one is a tower CSP and does not use PV modules.

Specially for scheme's type presented in Figure 8, we suggested to use as a high-temperature heat carrier the new liquid [12, 13] with good heat-transferring properties and with the addition of dye substituting the selective coating at the metal SR tube, which is fulfilled in this case from the high-strength glass. The scheme of PTC with such vacuum SR is presented in Figure 9.

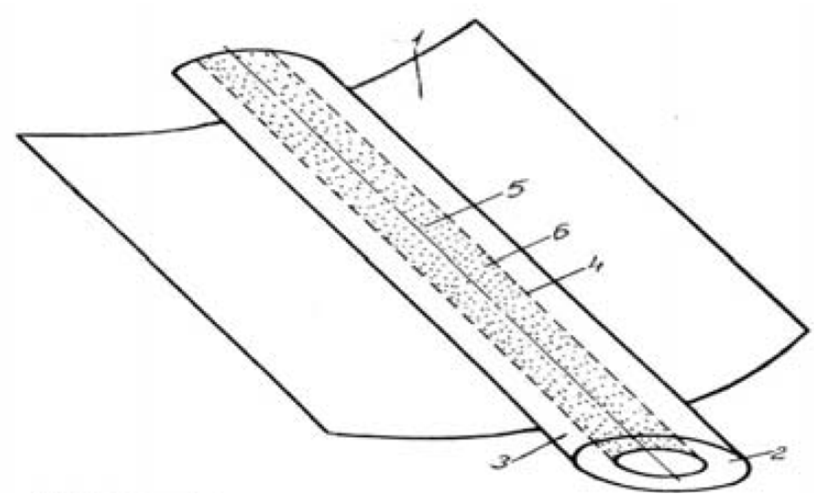

Figure 9. Solar receiver filled by high temperature heat carrier (oligodimethylsiloxane) and dye (diphtalocyanine of terbium, neodymium or lutetium): (1) PTC; (2) vacuum space; (3) glass envelope; (4) transparent tube; (5) heat carrier; and (6) dye-selective absorber of solar energy.

This selective absorber differ from the known melt of Na/K nitrates suggested comparatively recently and used successfully abroad at tower and PT CSPs. The optic and thermal characteristics of this heat carrier (Kabakov et al. [13]) suggested more than 10 years before the pointed melt of Na/K nitrates have been analyzed. For upper temperature, our heat carrier and pointed melt of nitrates are approaching one to other. But the freezing temperature of our heat carrier is substantially lower that constitutes its large advantage. Once more advantage is a possibility to feruse from the periodic substitution of selective coating in the construction of vacuum SR, when each time for its restoration it is necessary to disturb this construction formed for nitrated melt by the outside glass body and inside metal tube of SR.

Many large commercial PT and tower CSP are currently built or began to operate in the world. ENIN solved the whole series of problems for tower CSP (Kabakov [15]) in Crimea (Dubovenko et al. [16]; Baum [17]). The photos of SES-5 are presented in Figure 10. The tower with SR had a height 89m. The optical probe allowed turning heliostat in two planes. A number of heliostats was 1600, their area - $5 \times 5\text{m}^2$.

Figure 10. The tower of height 89m and optical probe for controlling the turn of heliostats in two planes are shown in photos; a number of heliostats is 1600, size $5 \times 5\text{m}^2$.

Two-axial solar tracking system was successfully tested and controlled by software developed for turning each heliostat. SES-5 existed up to the middle of 90s.

Many problems have been solved at the present time at tower CSPs of the world including the washing and cleaning from dust of large mirror surfaces of PTC and heliostats. The special washing liquids and mechanical devices for the effective automated cleaning of the mirrors with corresponding forms were developed abroad, especially in USA. By regret many of them are unknown in Russia. And some problem are not solved everywhere, though it was difficult to imagine their existence before. Before returning to them, let us mention about some CSPs constructed recently in the world.

2.2. CSP using the melt of Na/K sulphates in the world

The small tower CSP at melt of liquid metal salts began to work in 2013 in Spain and State Nevada (USA), where each CSP has a power 11MW, i.e., is practically not large distributed electricity source supplying 75000 houses with electricity. One from advantages of this system is a choice of salt melt as a heat carrier. The same melt could be used at the plants with PTC. The diagram of such plant is presented in Figure 11.

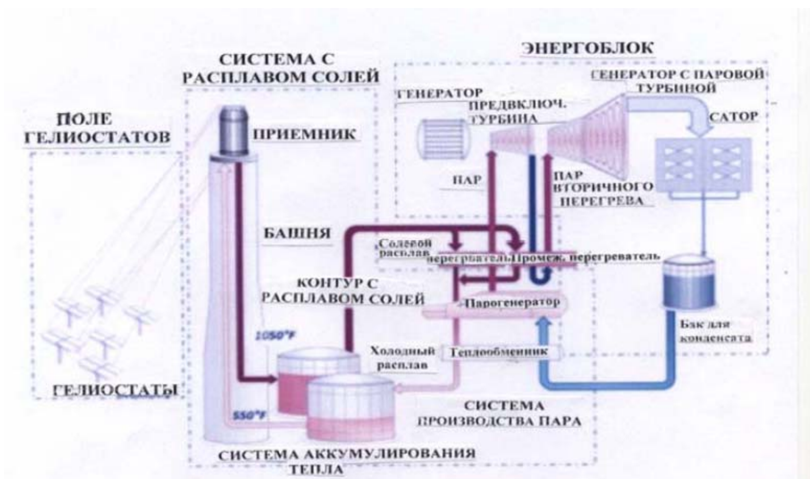

Figure 11. CSP using the central SR and working with the melt of liquid metals.

In China, where such plant is supposed to be constructed, it will be hybrid and be supplemented by boiler burning the willow and heating also the heat carrier Na/K.

The demonstration CSP (Novatec Solar [14]) at the South of Spain uses the melt of Na/K sulphates allowing to carry out the heating of this heat carrier up to 500ºC. The lenses Fresnel are used in this CSP as the reflectors. They are almost flat, are installed in row on steel base and concentrate the solar rays on SR similar to PTC. The heated melt is supplied after SR to the thermal accumulator. It allows generating electricity at this CSP in the time, when there is a need in it. It is supposed to master the long-time experience at not a large plant for using the accumulated experience or BAT for creating CSP of new generation.

The tower CSP with capacity 110MW will be built in Nevada by the end of 2014. This CSP contains more than 10034 heliostats and two accumulating tanks for 10 operating hours. The construction of CSP should be finished in December 2014. The plant will be located in 25km from Las-Vegas, while its area is 627 hectare. It was declared that CSP would have the higher efficiency than other systems (> 20%) with much less expenditures. Another new CSP «Tonopah» will use the two-axial system of heliostats tracking system similar to SES-5. The scheduled capacity of this tower CSP is 300MW.

The cases were known abroad, when the installation of thermal accumulators of tower and PT CSPs was carried out directly on the ground that resulted, as it was found out, in the considerable heat losses through the soil. It was necessary to install the accumulators on the supports for removing these losses.

2.3. Solution of unforeseen problems during CSPs operation

A capacity of largest in the world tower CSP «Ivanpah» in Californian desert Mojave constitutes 392MW. The view of towers at CSP «Ivanpah» and SRs installed on them is shown in Figure 12.

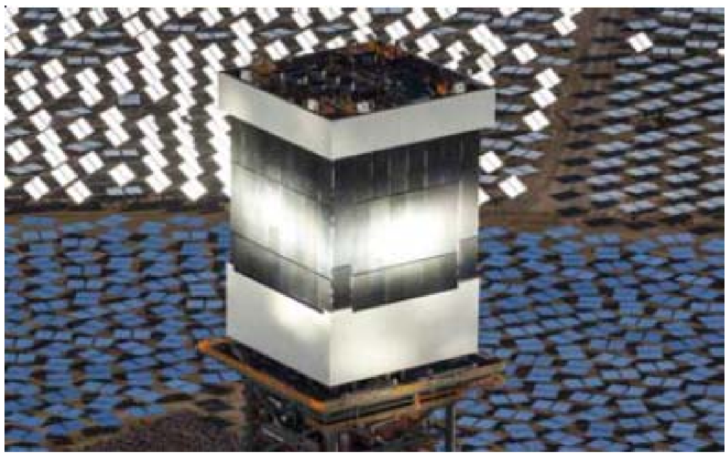

Figure 12. General view of CSP «Ivanpah» installed at the towers of SRs.

This CSP uses 350 thousand mirrors and is supplying the electricity to the consumers in California. It occupies the territory more than 1300 hectare and has about 350 thousand computer-controlled heliostats concentrating the solar rays at SRs-water boilers located on the tops of huge towers with height 140m. The water is transformed in steam setting in motion the turbo generators producing the ecologically clean energy. At the present time, the situation connected with using not all heliostats is analyzed. It is explained, in particular, by the different seasonal and weathering changes and by the fact that the CSP is intended only for covering the loads peaks in the beginning and at the end of day. However, it is not coordinated with the initial promises of designers, who “did not know supposedly” that the solar rays could not come at the part of heliostats because of not so far located mountain.

As it was found, the effect of reflected solar rays from heliostats for not working system became the main problem at the CSP «Ivanpah». The summary effect of reflected rays from many heliostats could result in the overshoot of limiting value of bright light (glint) intensity (Castillo [20]), while to complains from aircrafts pilots on the blinding effect of heliostats have entered already a few times. The software for controlling the safe position of reflectors was developed for the nonadmission of such situation.

The temperature around towers of «Ivanpah Solar Electric Generating System» can reach 600ºC. Therefore, though the advantages of ecologically clean energy are underlined in every possible way, the construction of such facilities brings up the new questions relatively their environmental hazard. The problem became evident quite recently, when the birds flying to mirrors and falling into the pointed solar flux were killed. In the first six months, 321 birds were killed when they were flying too nearby to the SRs of towers at the already working CSP “Ivanpah”. By using the birdscarer, a number of such cases was substantially decreased. These methods are well known in aviation and in the given case they are BATs. It is important during CSP downtimes to have the glare much less of its critical value, which should be determined. Just therefore the works are continued on finding the reasons of too bright reflected light. The condition of safe vision, when the eyes could see the heliostats without visible injuries at a certain distance.

The pointed phenomena for tower CSP should be taken into consideration in the modified software controlling the safe position of reflectors in idle time, as well as for putting the heliostats in the horizontal position during strong wind and storm (Kabakov [15]). The algorithm for determining the corresponding position of heliostats was developed after the serious work of specialists. The goal was the determination of heliostats position in any directions except the focal point above the tower, as it was before it. The experiments (Castillo [20]) carried out at CSP "Ivanpah" showed that the share was decrease after using the modified algorithm. Nevertheless, the works on decreasing the share are continued for determining the more accurate position of heliostats in not working state and for changing the geometry of ring dissipation in this case the reflected light. These measures should result in the considerable reduction of very bright light intensity.

It should be necessary to mention as well the PT CSP «Solana» in desert Arisona. The PT CSP passed the commercial tests, during which this CSP with capacity 280MW has generated the electricity even without sunlight. Two photos of this CSP are presented in Figure 13.

Figure 13. PT CSP «Solana» in Arisona.

2700 of parabolic mirrors at SPR «Solana» are tracked by sun position and concentrate the light on the tubes, in which the liquid heat carrier is flowing. After heating the heat carrier is coming in steam boilers, where it heats the water with forming steam. Steam rotates two turbines with capacity 140MW each generating the electricity. The CSP «Solana» is equipped with thermal accumulators being able to store the heat for electricity generation at night time. CSP could generate electric energy without using the mirrors up to six hours with maximal capacity, i.e., to satisfy the peak loads of State Arizona during the summer evening and early morning hours. This system is more stable in the work with network in comparison with wind and PVC plants. The area of each PTC constitutes 5.75×125m.

2.4. Optimal areas of application solar PT plants of different capacity

Niche, of the area of different solar concentrating plants application is very important, because it concerns the economic topics – expenses and payback periods. This problem is discussed currently and widely among specialists working in the area of using solar energy (Castillo [20]). In this connection, the more and more attention is paid to the industrial and domestic applications of corresponding technologies. At that, it should be taken into account that the PV plants with increasing their efficiency and decreasing the cost of steel became the cheaper alternative, while a problem of the attachment of thermodynamic CSP to network is still not solved in the total world or seems to be unreasonable because of low solar radiation in many regions.

The most part of Russian territory relates just to such regions. Only recently due to the heat accumulators and using the hybrid plants, it should be expedient to apply to such territories as Crimea, Transbaikalia or Yakutia for placing there CSPs.

Not high solar concentration makes more prospective for Russia the following industrial applications: water heating, heat supply, water lifting, steam production etc. The steam is widely used in India and Central Asia for processing and obtaining the food. It is also known about using of solar concentrators in India for water heating in automobiles production. The solar energy in Russia as abroad is widely used for water lifting. It is natural that the solar energy is required less with such applications than for CSP operation. In addition, not large solar plants occupy or demand the less area for their placement and are operating with the substantially lower temperatures. In particular, they are prospective for breweries, bakeries, processing food, in cellulose and textile industries. Therefore, it is much easier and cheaper to design and construct them. The natural fuels saving and ecological advantages of solar plants use make them quite attractive in the areas with sufficient inflow of solar energy and shortage of fuel.

As it is easy to assemble and dismount the small solar plants with concentrators, they are easy for transportation from place to place that makes them especially attractive, in particular for agricultural application. The small plants are less whimsical for the installation in the different territories than the large-scale CSPs, especially if to take into consideration the necessity of permissions for their construction and land utilization, the obtaining of which seems to be much simplier because of scales of withdrawn land. In the same time, there are the own problems for the small solar plants with concentrators. They are connected with their scale and correspondingly with the lower efficiency than the large CSPs have. But the small and large solar plants with concentrators have their own niches of areas of effective utilization. In the same time, the thermodynamic CSP hardly could complete with photovoltaic plants operating in network.

If to speak about the development of large CSPs, the main tendency of their development in addition to the already pointed applications is the increase in their capacity.

2.5. Hybrid thermophotovoltaic plants

It was suggested in ENIN to unify the both thermodynamic and photovoltaic methods in one CSP (Volkov et al. [8]). The PVC modules in such CSP (the schematic diagram of one from them is shown in Figure 8) are located in the part of SR, where it is possible to carry out the required cooling of PVSs. As a result, a number of PVCs working in the concentrated light is reduced, and the advantage of thermodynamic part connected with increasing time of its action due to the existence of heat accumulators is used. The tower CSP with large heat accumulators are more preferable for the commercial application and operation in network. But if the volume of accumulators is not large and if to take into account the expenditures for land utilization, the CSP with parabolic trough concentrators could be the good variant for choosing.

The data on new multipurpose PTC is now presenting (see Figure 14). It was developed and manufactured in Switzerland, where the large attention is paid to the renewable utilization (Steiner [21]). It has the concentration 2000, while it length is 57m. It could be a very useful BAT, and it is supposed to use it as a part of receiver for solar plant producing 100kW of thermal energy or a part of receiver for solar plant generating 20kW of electric energy. PTC could be used in the plants for water desalination of for air conditioning.

Figure 14. New multi-purpose thermophovoltaic concentrator.

This concentrator contains PVC assembly cooled by water and is able to convert up to 80% of solar light in the useful energy. It is the first known highly efficient photothermodynamic system with such high concentration factor developed by companies IBM and Airlight Energy. The companies want to master this breaking and new, by their words, technology by 2017. The description of similar systems of ENIN and some methods of their optimization is also given in (Kabakov and Levin [4]; Kabakov et al. [6]; Volkov et al. [8]; and Kabakov [19]). Twenty years needed for realization of some ideas of ENIN in the world. By regret they were also realized in Russia but only partly. The indicators of plant in Switzerland are extremely good and admirable. One-axial horizontal tracking system is specially developed for the CSP with capacity 12MW and such PT, which will be constructed in the center of France. The horizontal tracking system consists of 66 elements containing 36674 PVC assemblies. The system of these assemblies orientation on sun will increase the CSP efficiency up to 25%. It is supposed to prepare the tracking system to April 2015.

2.6. Advantages of large one-loop diagrams with PT concentrators and steam generation in SR

The one-loop CSPs with PT working by thermodynamic Rankine cycle are very prospective. In contrast from two-loop CSPs, they have a possibility of obtaining steam with the higher working parameters that results in the higher efficiency of CSP; there is no necessity to have the high-temperature heat carrier and intermediate heat exchangers. However, the problem of providing the hydraulic stability during steam generation in the branching field of PTC modules appears with realizing the one-loop schemes. The work on suppression of pressure pulsations under steam generation in long horizontal SP tubes was carried out in ENIN, and these works demand their continuation.

The works on development of moving SR joints in such PTC, when they are working under high parameters and must take the angular, connected with the SR displacements in space, and longitudinal, connected with the thermal expansion of solar receivers with the temperatures above 400^{o}C SR displacemets, were also carried out in ENIN. The view of PTC modules field at solar power plant “Solana” in California (USA) is shown once more in Figure 16, from which it is possible to judge about the possible SR displacements.

It was recommended in ENIN to use in the construction of movable joints the elements and joints, which showed themselves positively operating as a part of power equipment calculated for supercritical parameters.

Figure 15. Heliostats at CSP "Solana" for operation in California.

It was recommended in ENIN to use for PT the «sandwich» construction on the polyurethane base with thin mirror coating. The preliminary tests of such PT construction were carried out on water lifting plant in Crimea. Nevertheless, for recommendation of this proposal as a BAT, it is necessary to carry out the additional experimental-industrial tests under field conditions.

3. Conclusion

It should be noted finally that there are some additional measures and solutions, which could be recommended as BATs and will help to CSP to be widespread.

● In constructing CSPs, it should be taken into account that the large tower and parabolic trough plants become a part of general power system. Therefore, it is important to have the right choice of their placement, type and expenses for transmission lines and land use.

● It is unlikely currently and somewhere to rely only on the state support and financing of the projects. The recent examples of Spain and Australia, where it was refused in such support, show that it is more important increasingly to look for sponsors and financing organizations among the companies participating in realization of such projects. The funds of local administrations and foreign investors are also very important. By regret such resources were greatly converged in present time.

● The attempt to show the best available techniques (BATs) for CSPs was made in the article. Many of them were suggested some years ago in ENIN and many - recently at West. Many BATs differ greatly one from another but many have no many differences in general ideas. It is necessary to continue the works on development and search of BATs increasing CSP efficiency. It should be noted that a few technologies and schemes not reflected in this article was developed and suggested in ENIN. Some of them were presented in published material or at many local and international conferences.

● The main elements and equipment of CSP are nonstandard on development, manufacturing, and costs. Therefore, it is very important to reduce these expenses and a choice of corresponding BATs for the attraction of choosing the best creditors, designers and manufacturer. As to hardware for increasing CSP efficiency, it is necessary to increase the steam temperature, and here the mentioned high-temperature heat carrier are very appropriate as well as the thermal accumulators and the cheaper and more efficient accumulating materials in them. At that, it should be necessary to reduce the cost of all heat-accumulating system and the costs of all other systems and elements of CSPs. As the experience of already active CSPs shows, in addition to the general and mentioned expenses connected with heat accumulation system, the reaction and a rate of adjusting this system on the loading variations in power system are very important. Nevertheless, it should be noted once more that the existence of heat accumulation system is very important ands connected with the advantages, which the CSP with heat accumulators has in comparison with other technologies using the variable solar radiation.

● A number of highly qualified specialists and workers of all levels working with CSPs and at them decreased lately by the different reasons. One reason is connected with a large number of constructed and operating CSPs in the world and a shortage of specially prepared professional specialists. It is quite possible that it was the reason of severe injuries of construction personnel after fall of crane occurring quite recently during the construction of tower CSP in South Africa (CSP “Klu Solar One” developed by Spain in в Abengoa). Seven builders suffered, though some of them had the probation period in USA at CSP «Ivanpah». Six workers had the scalds in Spain itself in 2010 under unforeseen leakage of melt at CSP “Dehesa”. Though such cases are extremely seldom at CSPs, the training and retraining of the specialists of all ranks for working at CSP is actual and represents the necessary task. The fulfillment of safety technique requirements is also important in such nontraditional systems as CSPs, especially with working on height. It is so good that the training of young and highly qualified specialists for working with solar energy is widely carried out in our country in the universities of Moscow, Saint Petersburg, Tomsk and Yekaterinburg and in VIESH. It is only pity that there is little or no objects, where they could apply their knowledge and qualification.

● Returning to the importance of small autonomous and multi-purpose plants with PTs, it should be noted that the solar plants are simple, have the little costs for manufacturing and operation, are multifunctional and reliable in work, have the small payback period.

Biographical Notes

Vladimir I. Kabakov, PhD, Assistant Professor, has more than 350 publications and patents (in Russia and abroad) in the area of jet devices, renewable energy sources and *environmental* protection. His engineering activity was begun from the investigation and implementation of jet pumps (condensing injectors) working in the different power plants, in particular, working with renewable energy sources (solar and geothermal energy). Much his time was spent to the main elements of hybrid solar plants-parabolic trough and its heat collecting elements and to the heat and mass transfer intensification in the elements of plants with the change of phase (condensation and evaporation). Many his ideas were patented in Russia and other countries and many his works were translated and published abroad and reported at many international conferences. He has translated himself a large volume of materials as a translator and simultaneous interpreter. For many years he is a Manager of Department in JSC "Krzhizhanovsky Power Engineering Institute" in Moscow.

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