Fresh water for California

Self-payback options

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Summary

In the article the author considers a self-payback environmentally friendly Complex of equipment for supplying fresh water to the areas of California. The equipment complex receives water from the Pacific Ocean and, with the help of the Sun and a multi-stage evaporator, produces fresh water and dry sea salt. This complex allows to solve the ecological problem of water supply in this region after many years of drought. There are no technical problems, all technical solutions are known.

The current situation

Throughout history, California has experienced many droughts, such as 1841, 1864, 1924, 1928–1935, 1947–1950, 1959–1960, 1976–1977, 2006–2010, and 2012–2017. As the most populous state in the United States and a major agricultural producer, drought in California can have a severe economic as well as environmental impact.

California has one of the most variable climates of any U.S. state, and often experiences very wet years followed by extremely dry ones. The state's reservoirs have insufficient capacity to balance the water supply between wet and dry years. [1]

Although ocean desalination is a major source of drinking water in Israel, Saudi Arabia and other Middle Eastern counties, in California there are just five active ocean desalination plants that provide less than 1 percent of the state's drinking water.

The largest, by far, is a $1 billion plant on the coast in Carlsbad… it generates up to 56,000 acre-feet of water a year — roughly 8 percent of San Diego County's water supply. But the cost is high, from $2,131 to $2,367 an acre-foot, which is double the price… from other source. [2]

To date there are about 300 desalinization plants in the United States, with 120 in Florida and less than 40 each in Texas and California. Some 20 additional plants are planned for the coast of California in the coming years… [3]

The CA Department of Water Resources' 2009 Water Plan Update identifies the need for 275,000 AF of desalinated water by 2025. [4]

…With the majority of desalination plants extracting water directly through open water intakes in the ocean, there is a direct impact on marine life. Fish and other marine organisms are killed on the intake screens (impingement); organisms small enough to pass through, such as plankton, fish eggs, and larvae, are killed during processing of the salt water (entrainment)… Another major environmental challenge of desalination is the disposal of the highly concentrated salt brine that contains other chemicals used throughout the process. [5]

To critics, the plant is a costly mistake that will use huge amounts of energy and harm fish and other marine life… Almost every discussion about desalination begins and ends with cost. Desalinated water typically costs about $2,000 an acre foot… In Carlsbad, two gallons of seawater will be needed to produce each gallon of drinking water. For the Carlsbad plant Poseidon was required to build 66 acres of wetlands in San Diego Bay to offset the plant's environmental harm. It also must blend its brine at a 5:1 ratio with other seawater before flushing it back into the ocean so it won't harm marine life. Other projects will have to do all those things to get state permits. [6]

And from this requirement it follows that in the future for desalination it will be necessary to take from the ocean and return back 5 ... 6 times more the water.

Option for California

Consider a complex of equipment consisting of pumps, pipelines, water solar collectors, solar evaporative units, solar photovoltaic panels and inverters. The complex produces fresh water, for example, 200 million cubic meters per year for California. (The CA Department of Water Resources' 2009 Water Plan Update identifies the need for 275,000 AF of desalinated water by 2025 [4]). The complex is located to the east of Morro Bay. To obtain 200 million m^3 of fresh water by evaporative units, due to the energy of the Sun, the total area of the evaporative blocks should be 24 km^2.

Just 2 km from the city of Morro Bay we have huge empty mountainous areas, almost not used for economic purposes - see Fig.1. In Fig. 1 part of the mountainous areas is marked with a blue contour, its area is 100 km^2. The mountainous territory of 100 km^2 is quite sufficient for placing evaporative blocks with a total area of 24 km^2.

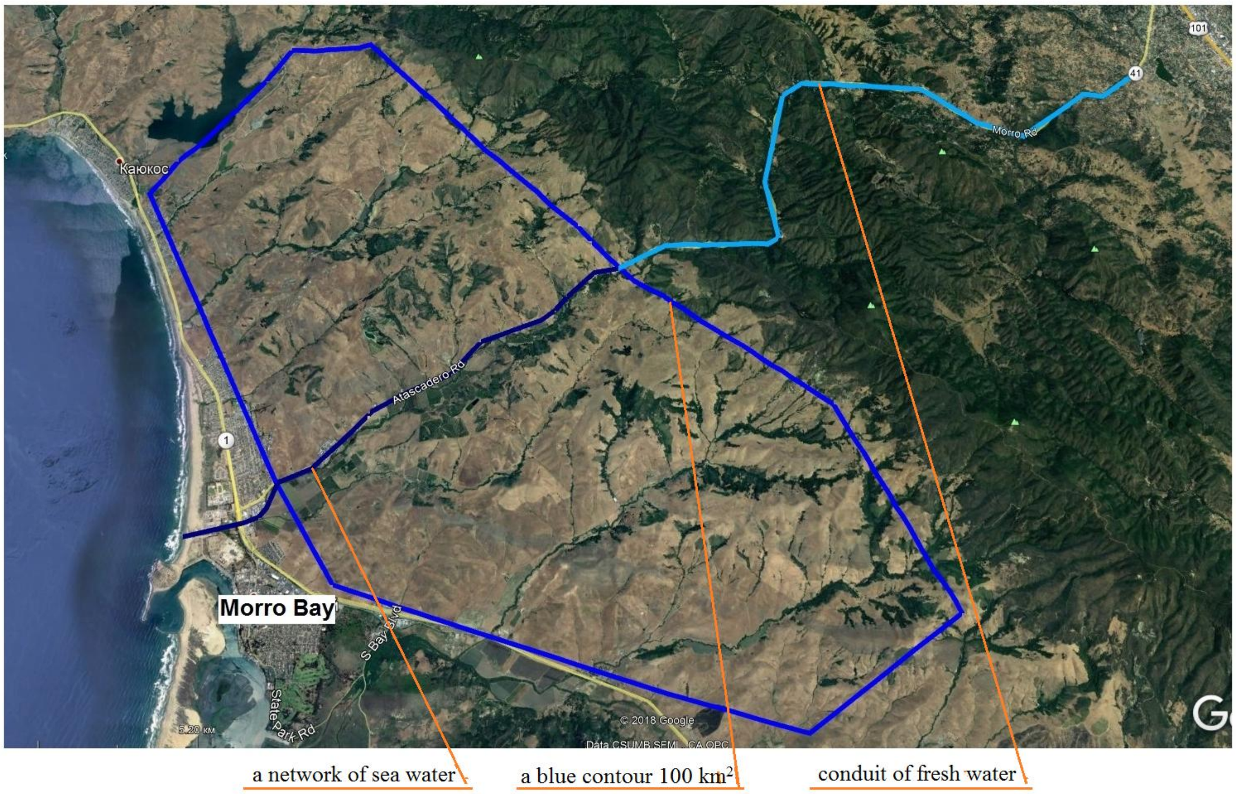

Fig. 1

The complex functions as follows. Pumps pump the water of the Pacific Ocean into a network of sea water. The seawater network is connected to each evaporation unit via an electric valve. Evaporative units have solar water collectors and solar photovoltaic panels. Solar photovoltaic panels provide energy for powering the equipment of the evaporator units and for powering the pumps. Fresh water - condensate is formed in evaporative units by means of multistage evaporation due to the energy stored in solar water collectors. Condensate is natural rainwater. Pumps supply fresh water to the network for consumers.

The technology considered is an environmentally friendly technology that makes it possible to produce fresh water from the sea water of the Pacific Ocean only with the help of the Sun. The equipment does not consume the "dirty" energy of power plants.

Solar multistage evaporative blocks are described in patents and publications, for example, [7]. In this article, a brief description of the block is given. Evaporative unit - see Fig.2 - has multi-stage evaporation baths 1 each with an area of 5 m^2, baths for complete evaporation 2 with a total area of 30 m^2, water solar collector 3 with a total area of 28 m^2 and photovoltaic solar panels 4 with an area of 6 m^2. All devices are placed on a foam plastic platform 5, the platform is installed on a dirt pad 6. The block occupies the territory of 42 m^2 (= 3 * 14).

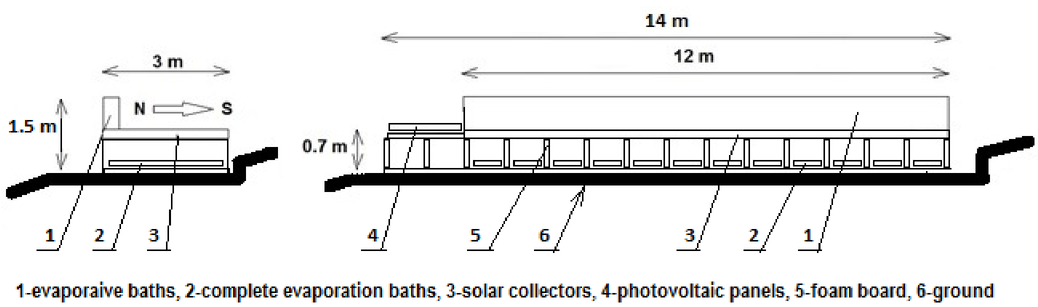

Fig.2

The evaporative unit produces one cubic meter of condensate per day and 320 m^3 per year, i.e. 7.6 million m^3 / km^2 * year (= 320 / 0.000042= 7.6 m^3 / m^2 * year). In California, we have an average of 320 sunny days per year. Of the 1 ton of sea water, the unit produces 750 kg of fresh water. Equipment for evaporation of water consumes 3 kWh per cubic meter of fresh water. The consumption of thermal solar energy is 111 kWh / m^3 = 96 kcal / kg of water.

Pumps, valves and other equipment are powered only from photovoltaic panels. The complex is completely autonomous: the Sun appeared, voltage appeared on the panels, inverters converted the voltage, the pump pumps water into the collectors, the water under the Sun warmed, the vapor condenses on the bottoms, condensate enters the fresh water network. The sun went down, the processes stopped. Today we have more energy of solar panels - we have more fresh water.

To produce 200 million cubic meters of fresh water a year, 270 million cubic meters of sea water (= 200 * 1000/750) should be supplied to the evaporating units. The average annual water flow is 9.8 m^3 / s (= 270,000,000 / 320 * 24 * 3,600). Evaporative blocks are located at altitudes from 10 to 300 m. Pumps raise sea water on average to a height of 155 m (= (10 + 300) / 2). The seawater network should have a cross-section of pipes that will ensure a pressure loss, for example, no more than 20 m. The pumps have a total average power of 19.3 MW (= 19,300 kW = 9.81 * 9.8 * (155 + 20) /0.87), consumes 464,000 kWh on average per day (= 19,300 * 24) and 148 million kWh per year (= 19,300 * 24 * 320). The efficiency of the pumps is assumed equal of 0.87. Pumps are powered from panels through inverters that have an efficiency of 0.95. The panels give the pumps 156 million kWh per year (= 148 / 0.95).

The average annual flow of fresh water is 7.2 m^3 / s (= 200,000,000 / 320 * 24 * 3600). Evaporative blocks are located at altitudes from 10 to 300 m, and the pass is at a mark of 440 m. Pumps raise fresh water on average by 285 m (from an average height of 155 m to 440 m). The fresh water network must have a cross-section of pipes that will ensure a pressure loss, for example, no more than 30 m. The pumps have a total average power of 25.6 MW (= 25,600 kW = 9.81 * 7.2 * (285 + 30) /0.87), consumes 614,000 kWh on average per day (=25,600 * 24) and 196 million kWh per year (=25,600 * 24 * 320). Pumps are powered from panels through inverters that have an efficiency of 0.95. The panels give to the pumps 207 million kWh per year (= 196 / 0.95).

Equipment for evaporation of water consumes 3 kWh per cubic meter of fresh water, per year the required energy is 600 million kWh (= 3 * 200). The total energy consumption by pumps and on evaporation amounts to 963 million kWh (=156+207+600).

The average annual performance of solar panels per day is 0.85 kWh / m^2 (= 5 kWh * 0.17 kW / m^2 / 1 kW / m^2), i.e. 0.85 million kWh / km^2 per day and 272 million kWh / km^2 per year (= 0.85 * 320). [8] For California, we take an average annual solar insolation of 5 kWh per day. We assume that the solar panels have a peak power of 0.17 kW / m^2.

For the production of 200 million cubic meters of fresh water per year, 625,000 evaporative units (= 200,000,000/320) are needed. Each block has solar panels with an area of, for example, $6m^2$. The total area of the panels is 3.75 km^2 (= 6 * 625,000 = 3,750,000). Panels in total produce 1020 million kWh of electricity per year (= 272 * 3.75). The energy that is used by the pumps and for evaporation amounts to 963 million kWh. Such a performance has a thermal power plant with a capacity of 125 MW (= 963,000,000/320 * 24).

The cost of desalinated water produced at the Carlsbad plant is between $ 2,131 and $ 2,367 per acre foot. This is twice the price from other sources [2], i.e. the price of water from other sources in California is about $1,120 per acre-foot (=(2113+2367)/2*2). Therefore, the water obtained in the evaporator blocks can have the same price of about $1 per cubic meter (1 acre-foot =1233 cubic meter). The cost of 200 million cubic meters of fresh water can be about $200,000,000 per year.

Each cubic meter of Pacific Ocean water contains 34 kg of salts. After complete evaporation of 270 million cubic meters of water in evaporative blocks, we obtain 9 million tons of dry sea salt per year (=0.034*270). The price of one ton of sea salt is in the world market from $ 10 to $ 40…100 [9, 10, 11]. The cost of dry salt obtained in evaporative blocks is at least $ 90 million per year. In 2013, the total world salt production was 264 million tons: five of the suppliers were China (71 million), the United States (40 million), India (18 million), Germany (12 million) and Canada (11 million) [10]. The United States will be able to add another 9 million tons to 40 million tons sea salt.

The complex of equipment, consisting of pumps, pipelines, solar evaporative units, solar photovoltaic panels and inverters, produces fresh water 200 million cubic meters per year, which can cost about $ 200 million and gives off dry sea salt, which costs at least $ 90 million.

Funds from the sale of fresh water and sea salt will be able to compensate for the costs of routine equipment maintenance and reimbursement of construction costs. Solar energy is a wonderful gift of Nature, but equipment, road construction and pipeline networks will naturally require financial investments. . The payback period of the considered Complex is undoubtedly less than the payback period of desalination plants.

The structure of the evaporation unit is made of foam plastic and other plastic materials and does not contain any metal structures. Metal is used only in valves, pumps and other equipment. Plastic pipes for sea and fresh water are laid on the surface and in trenches. This allows you to perform works on the widest possible front and shorten construction time and cost.

The considered version of the Complex is based only on the tests of the author of the operating models of the evaporator units. The model of the water solar collector had a surface area irradiated by the sun, 0.192 m^2. The model of the multi-stage evaporator had a bath area of 0.058 m^2. Before real design, R & D should be performed, and the characteristics of a full-size evaporative unit should be specified. The above calculations for real design should be specified taking into account the current standards.

Conclusion

1. There is no capital structures in the Equipment Complex considered: there are no water reservoirs, hydroelectric stations, tunnels, volumetric metal structures, concrete foundations. The largest building will be a building for the staff. This dramatically reduces the time and cost of construction. By its structure, the Complex allows to increase the number of evaporating units by stages in order to obtain the required amount of fresh water.
2. Reducing the consumption of ocean water and the lack of return of the brine to the ocean greatly facilitate the environmental situation and reduce the impact on the environment and marine life. On rain water millions of years, people, animals and plants developed, rainwater is the most biologically close to us, it is "living" water.
3. Figure 2 shows only the diagram of the evaporator unit. The firm that will implement the complex under consideration will get unlimited opportunities for a creative approach to developing new technical solutions and obtaining a large number of patents.

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