Fresh water for Eilat and Aqaba

Self-payback options

Addition to the project Red-Dead

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Summary

In the article the author considers the option of providing fresh water to Eilat and Aqaba areas. A self-payback complex of equipment for obtaining fresh water with the help of solar energy and a multi-stage evaporator is considered. The complex of equipment receives water from the Red Sea. With the help of the Sun, the Complex produces fresh water, commercial electricity and dry sea salt. The complex will solve the old ecological problem of water and electricity supply in this region. There are no technical problems, all technical solutions are known.

The current situation

For many years the humanitarians and politicans have been promoting various projects for pumping water from the Red Sea to the Dead Sea. Between the Government of Israel and the Kingdom of Jordan on 26 February 2015, an agreement was signed [Red-Dead Project], in which Jordan and Israel will jointly create a pipeline linking the Red Sea to the Dead Sea, a desalination plant north of Aqaba and a hydroelectric power station. The beginning of the project is expected in 2021: "... the annual collection of about 300 million cubic meters of water from the Red Sea is expected. Some of them will be desalted in a desalination plant, of which 30 million cubic meters will be transferred to the Jordan River, 35 million cubic meters into the Israeli settlements of Arava, and the rest of the Red Sea water complex will help to [prevent] the water level and begin to stabilize the Dead Sea. ... Phase A of the project is estimated at $ 1.2 billion. " [1]

"... In the future, the amount of [water] was planned to increase to 2 billion cubic meters. In Aqaba it was planned to build desalination plants with a design capacity of 100 million cubic meters per year ... ... Israel offered Jordan an alternative channel project that would link the Mediterranean Sea to the Dead, but Amman refused. The implementation of the project [Red-Dead] was to begin this year [2018], but the main stakeholders cannot reach an agreement. The divergence is so great that in the spring Jordan declared that it would start building the channel alone ... ".[2]

Short energy information. The difference in altitude from the Red Sea to the pass is 200 m, the pressure loss (in 80 km of the pipeline to the pass) is not less than 16 m. The water flow through the pumps and turbines will be 7.45 m^3 / s (= (300-65) / 365 * 24 * 3600). The power of the pumps will be 18 MW (= 9.81 * 7.45 * (200 + 16) /0.87=18,000 kW). The difference in altitude (from the pass to the hydropower station at the Dead Sea) is 600 m, the pressure loss (in 150 km of the pipeline) is at least 30 m. The possible capacity of the HPP will be 36 MW (= 9.81 * 7.45 * (600-30) * 0.87 = 36,000 kW). Of these 36 MW, the pumps use 18 MW, and the remaining 18 MW can be used for desalination.

To produce 65 million m^3 of desalinated water per year, no less than 325 million kWh of electricity is required (= 5 kWh / m^3 * 65 million m^3), those the power source must be at least 37 MW (= 325,000,000 / 365 * 24 = 37,000 kW). The desalination plant should receive 19 MW (= 37-18) from Jordan's power grid.

Features of the considered Options

Option for Eilat

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, 70 million cubic meters per year for Israel and Jordan and commercial electricity. (According to the Red-Dead project, they expect to receive 65 million m^3 of desalinated water.) The complex is located in the south-west from Eilat. To obtain 70 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 8 km^2.

On the western side of the bay we have huge empty mountainous areas that are 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 20 km^2. The mountainous territory of 20 km^2 is quite sufficient for placing evaporative blocks with a total area of 8 km^2.

Fig.1

The complex functions as follows. Pumps pump the water of the Red Sea into a network of sea water. The seawater network is connected to each evaporation unit via an electrovalve. 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, as well as for the electric grid for consumers. Fresh water is formed in the evaporative units by multi-stage evaporation due to the energy stored in the water solar collectors. Fresh water by gravity flows into the fresh water network for consumers.

Solar multistage evaporative blocks are described in patents and publications, for example, [3]. 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).

The evaporative unit produces one cubic meter of condensate per day and 360 m^3 per year, i.e. 8.6 m^3 / m^2 * year = 8.6 million m^3 / km^2 * year (= 360 / 0.000042). 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.

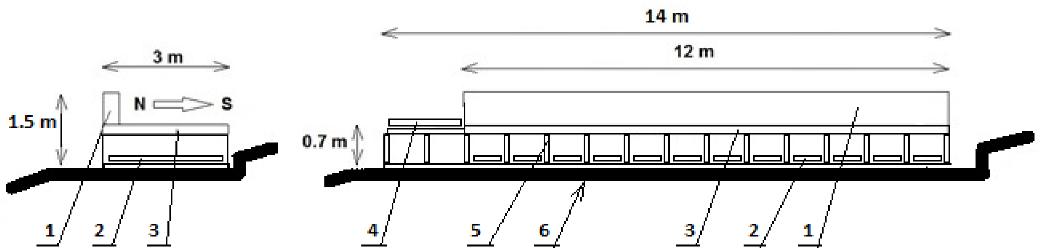

Fig.2

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, in the collectors the water under the Sun warmed, the vapor condenses on the bottoms, the condensate flows into the fresh water network. The sun went down, the processes stopped.

To produce 70 million cubic meters of fresh water a year, 93 million cubic meters of sea water (= 70 * 1000/750) should be supplied to the evaporating units. The average annual water flow is 3 m^3 / s (= 93,000,000 / 365 * 24 * 3,600). Evaporative blocks are located at altitudes from 50 to 330 m. Pumps raise sea water on average to a height of 190 m (= (50 + 330) / 2). The seawater network should have a cross-section of pipes that will ensure a loss of head, for example, no more than 20 m. The pumps have a total average power of 7 MW (= 7,000 kW = 9.81 * 3 * (190 + 20) /0.87), consumes 168,000 kWh on average per day (= 7,000 * 24) and 61 million kWh per year (= 7,000 * 24 * 365). Pumps are powered from panels through inverters that have an efficiency of 0.95. The panels give the pumps 65 million kWh per year (= 61 / 0.95).

Equipment for evaporation of water consumes 3 kWh per cubic meter of fresh water, per year the required energy is 210 million kWh (= 3 * 70). The total energy consumption by pumps and on evaporation amounts to 275 million kWh (= 65 + 210).

The average annual performance of solar panels per day is 0.935 kWh / m^2 (= 5.5 kWh * 0.17 kW / m^2 / 1 kW / m^2), i.e. 0.935 million kWh / km^2 per day and 341 million kWh / km^2 per year (= 0.935 * 365). [4]

For the production of 70 million cubic meters of fresh water per year, 200,000 evaporative units (= 70,000,000/360) are needed. Each block has solar panels with an area of, for example, 6m^2. The total area of the panels is 1.2 km^2 (= 6 * 200,000 = 1,200,000). Panels in total produce 409 million kWh of electricity per year (= 341 * 1.2). The energy that is not used by the pumps and for evaporation amounts to 134 million kWh (= 409-65-210). Commercial energy, which comes to consumers through inverters, is 127 million kWh (= 134 * 0.95). Such a performance has a thermal power plant with a capacity of 15 MW (= 127,000,000 / 365 * 24).

The cost of energy given to the grid is 45 million shekels a year (= 0.3545 * 127). The average annual tariff for desalination plants in Israel is 0.3545 shekels / kWh. [5] The cost of 70 million cubic meters of fresh water is 400 ... 600 million shekels a year. The tariff for water for consumers is 6 ... 9 shekels per cubic meter of water.

Each cubic meter of sea water contains 41 kg of salts. After complete evaporation of 93 million cubic meters of water in evaporative blocks, we obtain 4 million tons of dry sea salt (=41*93). The price of one ton of sea salt is in the world market from $ 10 to $ 40…100 [6, 7, 8]. The cost of dry salt obtained in evaporative blocks is at least $ 40 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) [8]. Israel (with 4 million) will be able to join the list of global suppliers of sea salt.

The complex of equipment, consisting of pumps, pipelines, water solar collectors, solar evaporative units, solar photovoltaic panels and inverters, produces annually fresh water at a cost of not less than 400 million shekels, transfers to the grid an energy of 45 million shekels and gives dry sea salt, which costs at least $ 40 million. In total, this amounts to $ 150 ... 200 million. The cost of the necessary equipment is of the same order.

Funds from the sale of fresh water, sea salt and electricity transferred to the grid will be able to compensate for the costs of routine equipment maintenance and reimbursement of construction costs. 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.

Solar energy is an excellent gift of Nature, but equipment, construction of roads and pipelines networks will naturally require financial investments.

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.

Option for Aqaba

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, 70 million cubic meters per year for Jordan and commercial electricity. (According to the Red-Dead project, they expect to receive 65 million m^3 of desalinated water.) The complex is located to the south from Aqaba. To obtain 70 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 8 km^2.

On the eastern side of the bay we have huge empty mountainous areas that are not used for economic purposes-see Fig.3. In Fig. 3 part of the mountainous areas is marked with a blue contour, its area is 20 km^2. The mountainous territory of 20 km^2 is quite sufficient for placing evaporative blocks with a total area of 8 km^2.

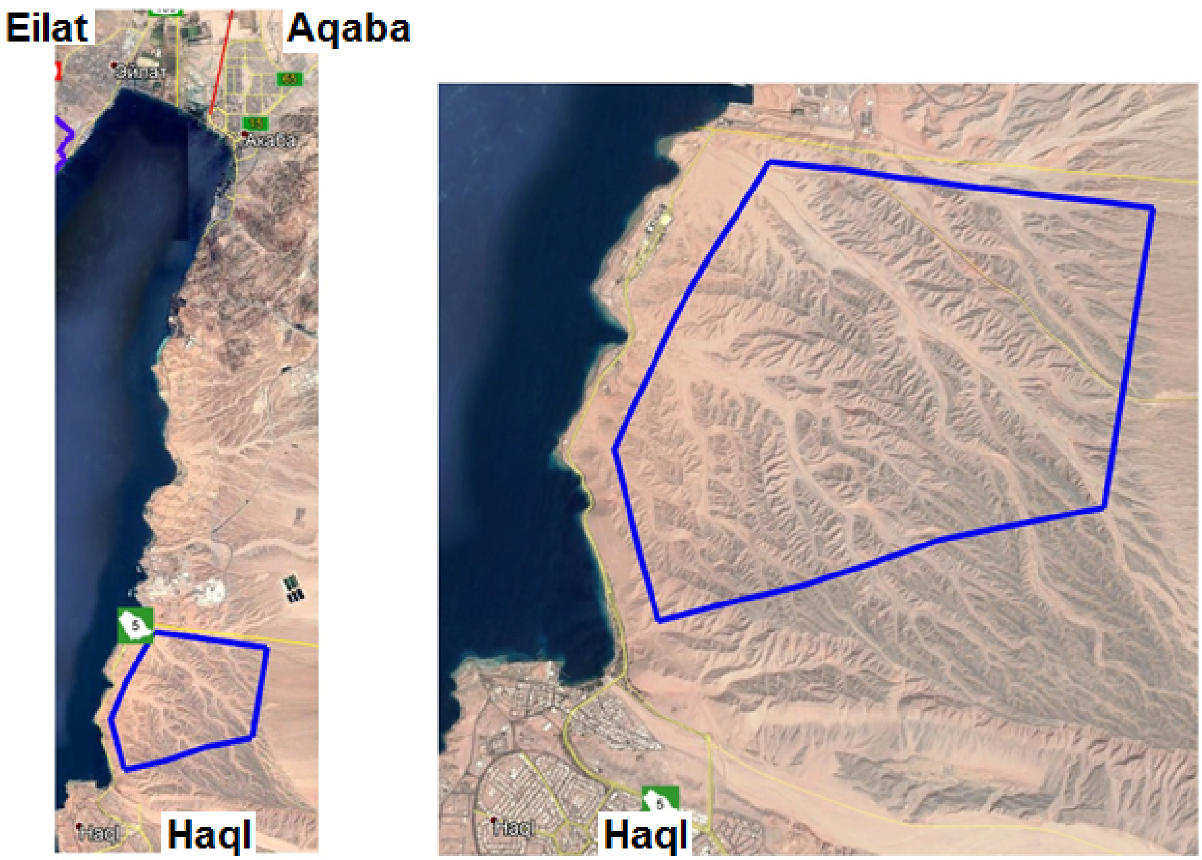

Fig.3

The complex functions as follows. Pumps pump the water of the Red Sea into a network of sea water. The seawater network is connected to each evaporation unit via an electrovalve. 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, as well as for the electric grid for consumers. Fresh water is formed in the evaporative units by multi-stage evaporation due to the energy stored in the water solar collectors. Fresh water by gravity flows into the fresh water network for consumers.

Solar multistage evaporative blocks are described in patents and publications, for example, [3]. 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).

The evaporative unit produces one cubic meter of condensate per day and 360 m^3 per year, i.e. 8.6 m^3 / m^2 * year = 8.6 million m^3 / km^2 * year (= 360 / 0.000042). 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.

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To produce 70 million cubic meters of fresh water a year, 93 million cubic meters of sea water (= 70 * 1000/750) should be supplied to the evaporating units. The average annual water flow is 3 m^3 / s (= 93,000,000 / 365 * 24 * 3,600). Evaporative blocks are located at altitudes from 50 to 250 m. Pumps raise sea water on average to a height of 150 m (= (50 + 250) / 2). The seawater network should have a cross-section of pipes that will ensure a loss of head, for example, no more than 20 m. The pumps have a total average power of 6 MW (= 6,000 kW = 9.81 * 3 * (150 + 20) /0.87), consumes 144,000 kWh on average per day (= 6,000 * 24) and 53 million kWh per year (= 6,000 * 24 * 365). Pumps are powered from panels through inverters that have an efficiency of 0.95. The panels give the pumps 55 million kWh per year (= 53 / 0.95).

Equipment for evaporation of water consumes 3 kWh per cubic meter of fresh water, per year the required energy is 210 million kWh (= 3 * 70). The total energy consumption by pumps and on evaporation amounts to 275 million kWh (= 65 + 210).

The average annual performance of solar panels per day is 0.935 kWh / m^2 (= 5.5 kWh * 0.17 kW / m^2 / 1 kW / m^2), i.e. 0.935 million kWh / km^2 per day and 341 million kWh / km^2 per year (= 0.935 * 365). [4]

For the production of 70 million cubic meters of fresh water per year, 200,000 evaporative units (= 70,000,000/360) are needed. Each block has solar panels with an area of, for example, 6m^2. The total area of the panels is 1.2 km^2 (= 6 * 200,000 = 1,200,000). Panels in total produce 409 million kWh of electricity per year (= 341 * 1.2). The energy that is not used by the pumps and for evaporation amounts to 144 million kWh (= 409-55-210). Commercial energy, which comes to consumers through inverters, is 137 million kWh (= 144 * 0.95). Such a performance has a thermal power plant with a capacity of 15.6 MW (= 137,000,000 / 365 * 24).

The cost of energy given to the grid is 49 million shekels a year (= 0.3545 * 137). The average annual tariff for desalination plants in Israel is 0.3545 shekels / kWh. [5] The cost of 70 million cubic meters of fresh water is 400 ... 600 million shekels a year. The tariff for water for consumers is 6 ... 9 shekels per cubic meter of water.

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Solar energy is an excellent gift of Nature, but equipment, construction of roads and pipelines networks will naturally require financial investments.

Conclusion

1. Construction of Complexes can be included in the Red-Dead project and should be quite acceptable for Jordan, because Jordan gets fresh water, electricity and jobs in a year or two, not after 5 ... 10 years.
2. Construction of Complexes can be carried out within the framework of the signed project Red-Dead: The complex will provide the missing capacity (15-19 MW) for the operation of the planned desalination plant. Because Phase A of the project is estimated at $ 1.2 billion, then an insignificant portion of this amount will be sufficient to conduct R & D on pilot evaporative units.

3. There are no capital structures in the considered Complexes of equipment: there are no water reservoirs, hydroelectric stations, tunnels, volumetric metal structures, concrete foundations. The largest construction will be a building for the staff. This dramatically reduces the time and cost of construction.
4. By its structure, the Complex allows to envisage (and subsequently increase) the number of evaporating units to obtain the required amount of fresh water and the number of solar photo panels to obtain the required commercial electricity.

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