Fresh water for the Kinneret Lake and the Dead Sea.

Self-payback options

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Scientific and Technical Association "Ecological imperative"

Summary

In the article, the author consider several options for replenishing by fresh water of the Kinneret Lake and the Dead Sea. In particular, the self-benefiting complex of facilities for obtaining fresh water with the help of solar energy and a multi-stage evaporator is considered. The complex of constructions uses water from the Mediterranean Sea. With the help of the Sun, the Complex produces fresh water, dry sea salt and commercial electricity. The complexes considered will allow solving the old ecological problems of the drying out Kinneret Lake and Dead Sea. There are no technical problems, all technical solutions are known.

The current situation

The majority well-known projects to save the Dead Sea include the construction of tunnels. Construction of the tunnel is the most expensive and the most prolonged part of the projects. It is understood that the construction of the complex will be unprofitable. The profit from some return of electricity through the HPP cannot compensate for either current expenses or billions of dollars invested in construction.
In December 2017, a report [1] appeared that "... The Israeli Water Resources Authority is considering the possibility of constructing a water conduit that will inject desalinated water into the rapidly dying Kinneret Lake because of the prolonged drought."

In June 2018 it was reported [2], in particular, that "... until 2030 the authorities [of Israel] plan to pump one billion cubic meters of water per year into the lake." In addition, it was noted: "However, a number of specialists warn that the purification of water from salts requires high monetary and energy costs, which can adversely affect the environment." In another publication [3], they write: "These installations [reverse osmosis] are very expensive, after all. Similar to those that operate in Israel - I mean the "big five" - cost is one billion shekels each. "

The content of the Water Resources Management Project was not found on the Internet. Therefore, in this article, we consider some of the options that are possible, in the opinion of the author.

Features of the considered Options

1st Option
Consider a complex of constructions, consisting of desalination plant, water conduits, pumping station and water-power plant. The complex provides desalted water for the Kinneret Lake, for example, 500 million cubic meters per year. In the old days so much water was taken from the

lake. The desalination station can be on the shore, on a barge or on an artificial island. The choice of station location is determined for economic reasons.
The water conduit is laid from the coast of the sea north of Haifa to the southern shore of the Kinneret Lake. The water conduit is constructed by an open method - by laying pipes on the surface and in trenches. Such a construction of the water conduit will allow the work to be carried out with the widest possible front. This will significantly shorten construction time and cost.

By water conduit from the Mediterranean Sea is supplied with 500 million cubic meters of water per year. The length of the water conduit is 72 km, at the 57th km the upper point of the water conduit is at 150 m - see Fig.1. The water-power plant is located on the 59th km on a mark of minus 200 m. Pumping station and water-power plant operate 24 hours 7 days 168 hours a week. The flow of water in pumps and turbines is 16 m^3 /s. The pumps receive energy from the water-power plant.

The water conduit has 2 threads with a diameter of 3 m. Loss of pressure is H=21 m ($H=Q^2 *L/F^2 *C^2 *R$) [4]. The pressure created by pumps is 171 m (= 150 + 21).The total electrical power of the pumps is 31 MW(=31 000 kW = 9.81*16*171/0.87). Pressure in turbines of the water-power plant is 349 m. The electrical capacity is 48 MW (=48 000 kW = 9.81*16*349*0.87). The water conduit from the water-power plant to the Kinneret Lake has 2 threads with a diameter of 3 m, a length of 13 000 m. Loss of pressure is 5 m [4]. The difference in levels from the water-power plant to the Kinneret Lake is 17 m, so the water flows by gravity.

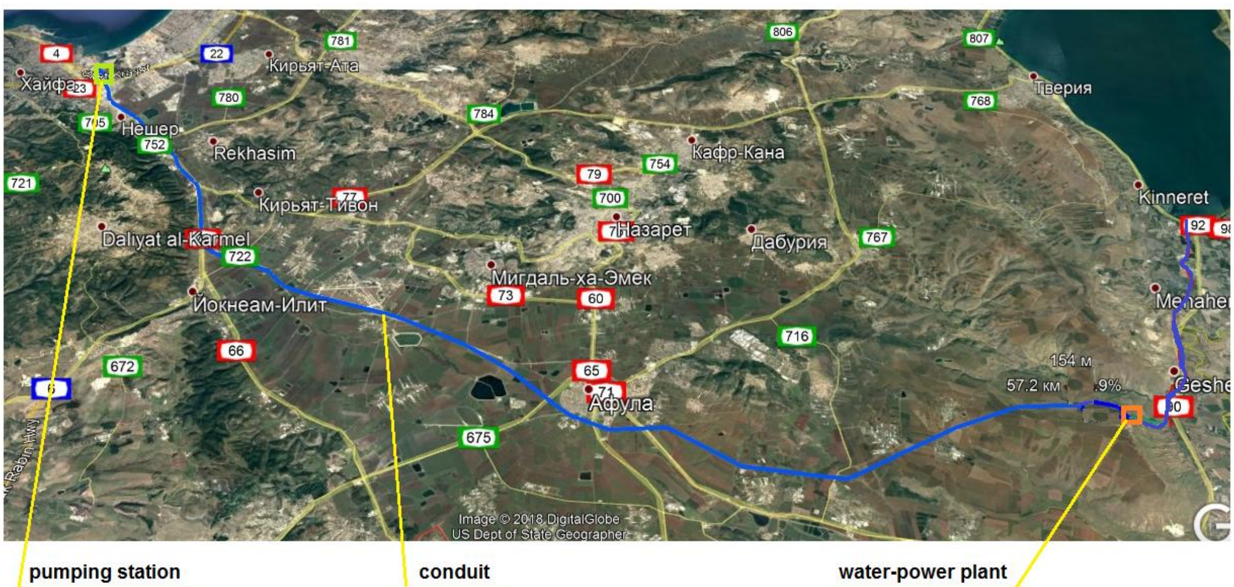


Fig. 1
Generators have a capacity of 48 MW, pumps capacity is 31 MW, 17 MW are returned to the grid. The cost of kWh is 0.3545 shekels / kWh on average per year [5]. In Israel, for desalination enterprises there is a table of electricity tariffs. Tariffs vary according to the seasons, days of the week and by the hour. The returned energy is 148,000,000 kWh per year (=17,000*168*52), which costs 53 million shekels (=0.3545*148,000,000).

The energy costs for the production of fresh water by reverse osmosis are 5 ... 8 kWh / m^3. The production of 500 million m^3 of water requires an energy of at least 2,500 million kWh (= 5 * 500), which costs 890 million shekels (=0.3545*2,500,000,000). The cost of consumed energy is 17 times (= 890/53) higher than the cost of energy returned through the water-power plant.

Thus, the Complex of constructions, consisting of desalination plant, water conduits, pumping station and water-power plant (total cost of billions of dollars) requires daily payment of consumed electricity and payment for current maintenance of all facilities.

2nd Option

Consider a complex of structures, consisting of solar evaporative blocks, water conduits, pumping stations, water-power plant and a small reservoir on the eastern shore of the lake. The complex produces fresh rainwater for Kinneret Lake, for example, 500 million cubic meters per year. In the old days so much water was taken from the lake.

Solar evaporative blocks are located in the east of the Kinneret Lake. To obtain 500 million cubic meters of fresh water with the help of solar energy a total area of 50 km^2 blocks is required.

Solar multistage evaporative blocks are described in patents and publications, for example, [6]. In this article we give a brief description. The evaporation block - see Fig.2- has solar collectors 3 with a total area of 28 m^2, 7 evaporating baths 1 each with an area of 5 m^2, a bath for complete evaporation 2 with an area of 30 m^2 and a photovoltaic solar panel 5 with a capacity of 600-700 W. The evaporative unit produces one cubic meter of condensate per day. The total area of the block is 36 m^2.

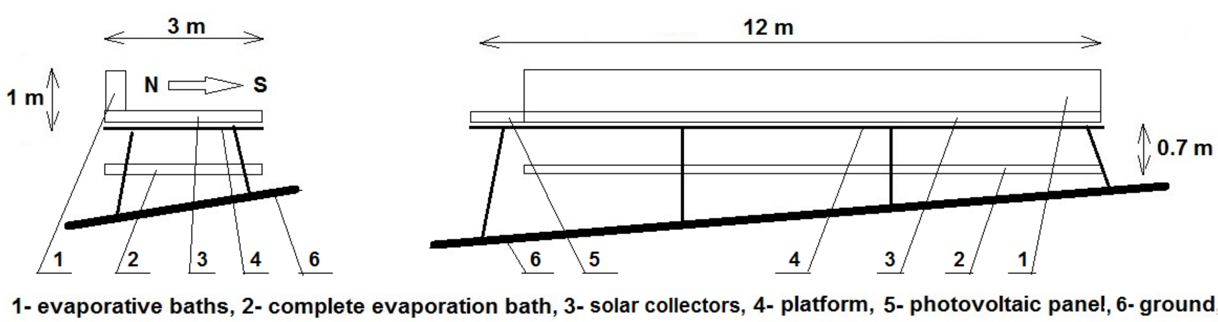


Fig. 2

Evaporative baths are located one above the other. The original sea water is fed to the upper evaporative bath through the valve. The valve is connected to the network with sea water. Water from the upper baths merges into the lower ones through the drain pipes. The water vapor of the lower baths condense on the bottom of the upper baths. Condensate is pumped by the pump into a network of fresh water. The brine from the lower evaporating bath is drained through the valve into a bath for complete evaporation.

The pump, valves and other control equipment are powered only from the photovoltaic panel. The evaporative block is completely autonomous: the Sun appeared, voltage appeared on the panel, the water under the Sun became hot, the vapors are condensing on the bottom, the condensate is pumping into the fresh water network. The sun went down, the processes stopped.

Specific consumption of thermal solar energy is 111 kWh / ton = 96 kcal / kg of source water. . The evaporation unit produces 360 cubic meters of condensate per year from an area of 36 m^2 = 0.000036 km^2, i.e. we have 360 m^3 / 36 m^2 * year = 10 million m^3 of water / km^2 * year.

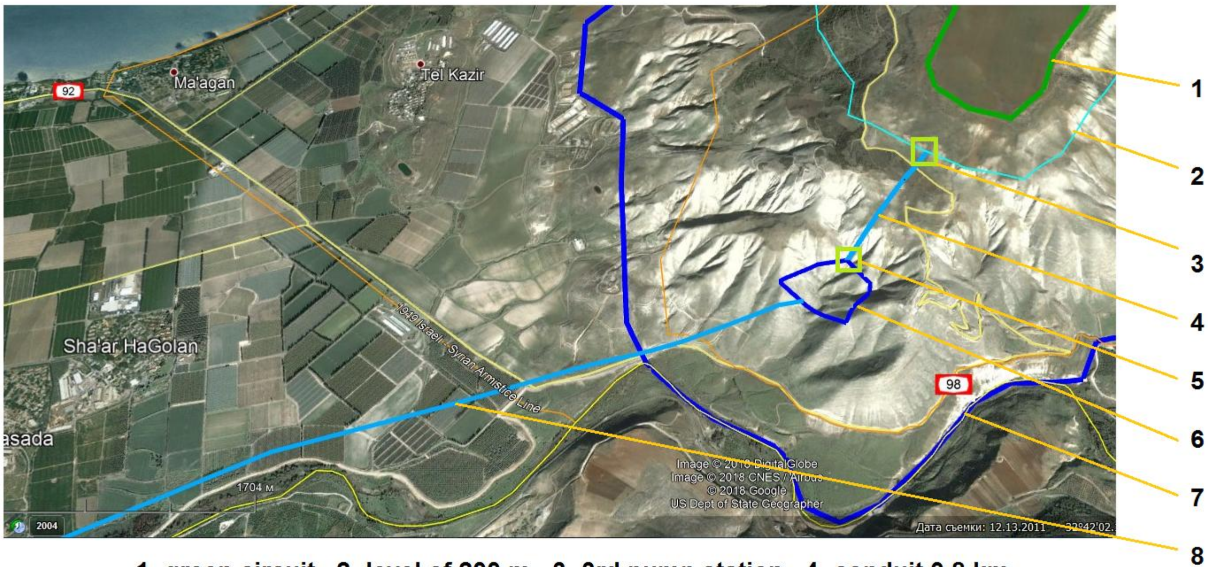
A huge area, it would seem! But…! On the eastern side of the lake we have huge empty mountainous areas that are not used for economic purposes-see Fig.3, 4. In Figure 3, 4, part of the mountainous areas is marked with a blue contour, its area is 90 km^2. Inside the blue contour we have green contours - these are the territories used - settlements, agricultural enterprises, etc. The total area of the territories used is 15 km^2 as of 2011. The remaining mountainous area of 75 km^2 can be used to accommodate evaporative blocks with a total area of 50 km^2.

One ton of Mediterranean Sea water contains 39 kg of salt and 961 kg of water. Of one ton of source water, 875 kg of water evaporate in 7 baths. From the bottom evaporating bath 125 kg of brine is poured into the 8th bath for complete evaporation. In the 8th bath, 86 kg water is completely evaporated, and 39 kg of sea salt remains in the bath. From the upper bath, 125 kg of water evaporate into the ambient air. Condensate of 750 kg from 6 baths are collected and pumped into the fresh water network. Of the one ton of source water, we have 750 kg of fresh water. The resulting water is a natural, actually rainwater, but only cleaner than the rains in Israel, because does not collect dust and other contaminants from the surrounding atmosphere. In the ambient air, 211 kg of water (= 125 + 86) evaporates.

To produce 500 million cubic meters of fresh water per year, 667 million cubic meters of sea water (= 500 * 1,000/750) should be supplied to the evaporative blocks. In addition, 140 million cubic meters of water (= 500 * 211/750) evaporate into the ambient air from the total area of the baths of 50 km^2 (= (5 + 30) * 500/360). We get quasi a lake with sea water with an area of 50 km^2. The area of the Kinneret Lake is about 160 km^2.

The water conduit is laid from the coast of the Mediterranean Sea north of Haifa to the eastern shore of the Kinneret Lake - see Fig. 3, 4. The water conduit is constructed by an open method - by laying pipes on the surface and in trenches. Such a construction of the water conduit will allow the work to be carried out with the widest possible front. This will significantly shorten construction time and cost.
The length of the water conduit is 71 km, at the 58th km the upper point of the water conduit is at 150 m. Sea water enters the body of water, located to the east of the lake on a mark of minus 20 m. The body of water has an area of 0.12 km^2 and a volume of 2.5 million m^3. Pumping stations

on the water conduit are located: the first in the Haifa area, the second at a level minus 20 m after the body of water, the 3rd at a level of +200 m. Pumps lift part of the water to a level of only 0 m, part of the water - to a level of 350 m. The water-power plant is located at the level of minus 210 m on the shore of the lake - see Fig. 3, 4.



1- green circuit, 2- level of 200 m, 3- 3rd pump station, 4- conduit 0.8 km,
5- 2nd pump station, 6- 0.12 km2 reservoir, 7- blue contour 90 km2, 8- conduit 71 km

Fig. 3

Fig. 4.

Pumps of the 1st station work 24 hours 7 days 168 hours a week and receive power from the power grid. The average water flow through the 1st pumping stations is 21 m^3 / s (=667,000,000/365*24*3,600). Other pumping stations and water-power plant work only in sunlight, when the evaporation blocks give out fresh water. In the summer it is about 12 hours, in the winter - about 8 hours a day. The average water flow through the 2nd and 3rd pumping stations is 51 m^3 / s (=667,000,000/365*10*3,600).

The difference in levels from the Mediterranean Sea to the body of water is minus 20 m. The water conduit has 2 threads with a diameter of 3 m. Loss of pressure is H=45 m($H=Q^2 *L/F^2 *C^2 *R$) [4]. The pressure created by pumps is 25 m (= -20+45). The total electrical power of the pumps is 6 MW (=6,000 kW = 9.81*21*25*0.87).

The water conduit from the reservoir has 2 threads with a diameter of 3 m and a length of 0.8 km. The average water flow is 51 m^3 / s (=667 000 000/365*10*3600). Loss of pressure is H=3 m. [4]. The pressure created by pumps is 223 m (= +20+200+3). The total electrical power of the pumps is 128 MW (=128 000 kW = 9.81*51*223/0.87).
Each evaporative block has a pump that pumps fresh water into the fresh water network. Pressure in the fresh water network is maintained at 370 m. The freshwater network must have such a cross-section of pipelines which will ensure a loss of pressure, for example, no more than 20 m. The flow of fresh water from the evaporator block averages 0.028 liters / is (= 1/10 * 3600). The pump power of each unit must be at least 0.27 kW (= 9.81 * 0.00006 * 370 / 0.8). The water-power plant is at the level of minus 210 m. Pressure in turbines of the water-power plant is 560 m (=370+210-20). 500 million cubic meters of fresh water is passed through turbines in year on average for 10 hours a day. The average water flow through the turbines is 38 m^3 / s (=500,000,000/365*10*3,600). The electrical capacity is 180 MW (=180,000 kW = 9.81*38*560*0.87). Fresh water comes from the water-power plant into the lake.

The generators have a capacity of 180 MW, the total power of the pumps is 134 MW (= 128 + 6). Pumps consume energy per day of 1,424,000 kWh (=6,000*24+128,000*10). The generators produce 1,800,000 kWh per day (=180,000*10). On average, per day, generators return 376,000 kWh (= 1,800,000-1,424,000) to the grid and 137,000,000 kWh per year. The cost of kWh is 0.3545 shekels / kWh on average per year [5]. In Israel, for desalination enterprises there is a table of electricity tariffs. Tariffs vary according to the seasons, days of the week and by the hour. The returned energy is 137,000,000 kWh per year costs 49 million shekels (=0.3545*137, 000,000).

Each cubic meter of sea water contains 39 kg of salts. After complete evaporation of 667 million cubic meters of water in evaporative blocks, we obtain 26 million tons of dry sea salt. The price of one ton of sea salt is in the world market from $ 10 to $ 40…100 [7, 8, 9]. The cost of dry salt, obtained in evaporative blocks, is not less than 1/4 billion dollars a 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 26 million) will be able to become one of the world's major suppliers of sea salt.

The complex of structures, consisting of solar evaporative blocks, water conduits, pumping stations, water-power plant and a small reservoir, produces 500 million cubic meters of fresh water a year for the replenishment of the Kinneret Lake, transmits energy to 49 million shekels and provides dry sea salt, which costs not less than 1/4 billion dollars.

Funds from the sale of salt and returned energy to the network will be able to compensate for the costs of routine maintenance of all facilities and reimbursement of construction costs. In addition to 500 million m^3 of fresh water, we get a quasi lake with sea water with an area of 50 km^2. 140 million m^3 of water per year evaporates from the surface of this lake. Fresh practically rainwater, therefore living water, will prevent salinization of the lake and will please the flora and fauna of the lake and all citizens of Israel.

Evaporative blocks are made of plastic materials. Metal is used only in valves, pumps and other equipment. Solar energy a wonderful gift of Nature, but the manufacture of equipment and the construction of roads and a network of pipelines will naturally require financial investments. . It is possible that for the recovery of the Kinneret Lake it is considered that it is enough to build the Complex with a capacity of only 200 ... 300 million cubic meters of fresh water.

The considered 2-nd variant are based only on tests of the author of the working model of the evaporator. The model had a surface area irradiated with the sun 0.192 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 should be specified taking into account the current standards.

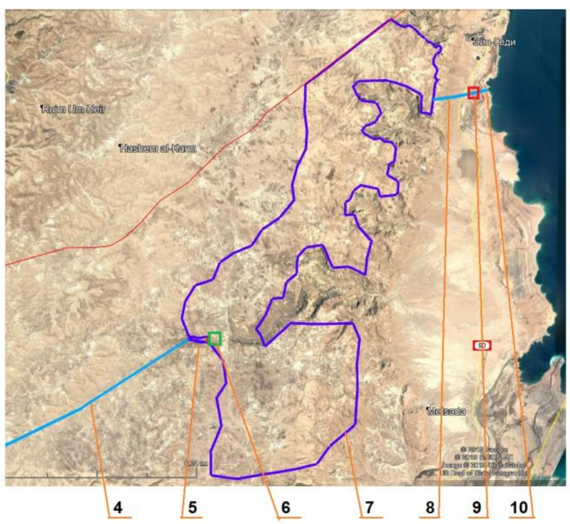
3rd Option.

Consider a complex of structures, consisting of solar evaporative blocks, water conduits, pumping stations, water-power plant and a small reservoir (at a level of 300 m) over the western shore of the Dead Sea. The complex produces fresh rainwater for the Dead Sea, for example, 500 million cubic meters per year. Solar evaporative blocks are located the west of the Dead Sea. To obtain 500 million cubic meters of fresh water with the help of solar energy a total area of 50 km^2 blocks is required.

A huge area, it would seem! But…! To the west of the Dead Sea we have huge empty mountainous areas that are not used for economic purposes-see Fig.5, 6. In Figure 5, 6, part of the mountainous areas is marked with a blue contour, its area is 77 km^2 as of 2011. The remaining mountainous area of 77 km^2 can be used to accommodate evaporative blocks with a total area of 50 km^2.

1- 1st pumping station, 2- 2nd pumping station, 3- 3rd pump station, 4- conduit 88.5 km, 5- 0.13 km2 reservoir, 6- 4th pump station, 7- blue contour 77 km2, 8- conduit 1.6 km, 9- water-power plant, 10- open channel

Fig. 5



4- conduit 88.5 km, 5- 0.13 km2 reservoir, 6- 4th pump station,
7- blue contour 77 km2, 8- conduit 1.6 km, 9- water-power plant, 10- open channel

Fig. 6

Solar multistage evaporative blocks are described in patents and publications, for example, [6]. In this article we give a brief description. The evaporation block - see Fig.2- has solar collectors 3 with a total area of 28 m^2, 7 evaporating baths 1 each with an area of 5 m^2, a bath for complete evaporation 2 with an area of 30 m^2 and a photovoltaic solar panel 5 with a capacity of 400-500 W. The evaporative unit produces one cubic meter of condensate per day. The total area of the block is 36 m^2.

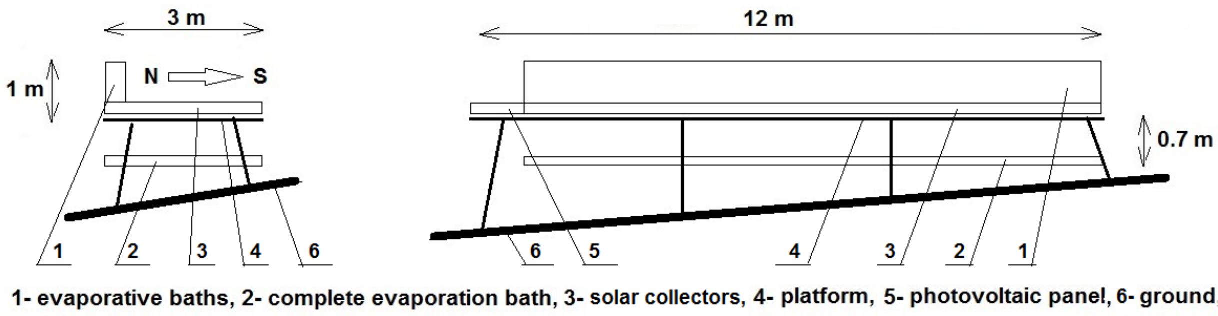


Fig. 2

Evaporative baths are located one above the other. The original sea water is fed to the upper evaporative bath through the valve. The valve is connected to the network with sea water. Water from the upper baths merges into the lower ones through the drain pipes. The water vapor of the lower baths condense on the bottom of the upper baths. Condensate is pumped by the pump into a network of fresh water. The brine from the lower evaporating bath is drained through the valve into a bath for complete evaporation.

The pump, valves and other control equipment are powered only from the photovoltaic panel. The evaporative block is completely autonomous: the Sun appeared, voltage appeared on the panel, the water under the Sun became hot, the vapors are condensing on the bottom, the condensate is pumping into the fresh water network. The sun went down, the processes stopped.

Specific consumption of thermal solar energy is 111 kWh / ton = 96 kcal / kg of source water. . The evaporation unit produces 360 cubic meters of condensate per year from an area of 36 m^2 = 0.000036 km^2, i.e. we have 360 m^3 / 36 m^2 * year = 10 million m^3 of water / km^2 * year.

One ton of Mediterranean Sea water contains 39 kg of salt and 961 kg of water. Of one ton of source water, 875 kg of water evaporate in 7 baths. From the bottom evaporating bath 125 kg of brine is poured into the 8th bath for complete evaporation. In the 8th bath, 86 kg water is completely evaporated, and 39 kg of sea salt remains in the bath. Condensate of 750 kg from 6 baths are collected and pumped into the fresh water network. Of the one ton of source water, we have 750 kg of fresh water. The resulting water is a natural, actually rainwater, but only cleaner than the rains in Israel, because does not collect dust and other contaminants from the surrounding atmosphere. In the ambient air, 211 kg of water (= 125 + 86) evaporates.

To produce 500 million cubic meters of fresh water per year, 667 million cubic meters of sea water (= 500 * 1000/750) should be supplied to the evaporative blocks. In addition, 140 million cubic meters of water (= 500 * 211/750) evaporate into the ambient air from the total area of the baths of 50 km^2 (= (5 + 30) * 500/360). We get quasi a lake with sea water with an area of 50 km^2. The area of the northern Dead Sea basin is about 650 km^2.

The water conduit is laid from the Mediterranean coast north of Ashkelon to the western shore of the northern Dead Sea basin - see Fig. 5, 6. The water conduit is constructed by an open method - by laying pipes on the surface and in trenches. Such a construction of the water conduit will allow the work to be carried out with the widest possible front. This will significantly shorten construction time and cost.

The length of the water conduit is 88.5 km, at the 74th km the upper point of the water conduit is at 530 m. Sea water enters the body of water, located on a mark of 300 m. The body of water has an area of 0.13 km^2 and a volume of 1.2 million m^3. Pumping stations on the water conduit are located: the first in the Ashkelon area, the second at a level 170 m, the 3rd at a level of 350 m, 4th on the level of 300 m after the body of water. The water-power plant is located at the level of minus 410 m on the shore of the northern basin - see Fig. 5, 6.

Pumps of the 1st, 2nd and 3rd station work 24 hours 7 days 168 hours a week and receive power from the power grid. The average water flow through the 1, 2, 3 pumping stations is 21 m^3 / s (=667,000,000/365*24*3,600). 4th pumping stations and water-power plant work only in sunlight, when the evaporation blocks give out fresh water. In the summer it is about 12 hours, in the winter - about 8 hours a day. The average water flow through the 4th pumping stations is 51 m^3 / s (=667,000,000/365*10*3,600).

The difference in levels from the Mediterranean Sea to the body of water is 300 m. The water conduit has 2 threads with a diameter of 3 m. Loss of pressure is H=56 m ($H=Q^2 *L/F^2 *C^2 *R$) [4]. The pressure created by pumps is 356 m (= 300+56). The total electrical power of the 1, 2 , 3 pumps is 84 MW (=84,000 kW = 9.81*21*356/0.87).

Seawater from the water conduit enters the seawater network, to which all evaporative units are connected. The seawater network must have such a cross-section of pipelines which will ensure a loss of pressure, for example, no more than 30 m. Evaporative units are located at the level of 100 ... 320 m inside the blue contour - see Fig. 5, 6. The total pressure loss is therefore 50 m (= + 20 + 30). The total electrical power of the pumps is 29 MW (=29,000 kW = 9.81*51*50/0.87). Each evaporative block has a pump that pumps fresh water into the fresh water network. Pressure in the fresh water network is maintained at 440 m. The freshwater network must have such a cross-section of pipelines which will ensure a loss of pressure, for example, no more than 30 m. The flow of fresh water from the evaporator block averages 0.028 liters / is (= 1/10 * 3600). The pump power of each unit must be at least 0.33 kW (= 9.81 * 0.00006 * 440 / 0.8).

The fresh water network is connected to the water conduit to the water-power plant. The water conduit to the water-power plant, which is 1.6 km long, has 2 threads with a diameter of 3 m. The average water flow through the water-power plant is 38 m^3 / s (=500,000,000/365*10*3,600). Loss of pressure is H=4 m. ($H=Q^2 *L/F^2 *C^2 *R$) [4]. The water-power plant is at the level of minus 410 m. Pressure in turbines of the water-power plant is 816 m (=440+410-30-4). The electrical capacity is 265 MW (=265, 000 kW = 9.81*38*816*0.87). Fresh water comes from the water-power plant into the northern Dead Sea basin.

The generators have a capacity of 265 MW, the total power of the pumps is 113 MW (= 84 + 29). Pumps consume energy per day of 2,300,000 kWh (=84,000 *24+29,000*10). The generators produce 2,650,000 kWh per day (=265,000*10). On average, per day, generators return 350,000 kWh (=2,650,000 -2,300,000) to the grid and 128,000,000 kWh per year. The cost of kWh is 0.3545 shekels / kWh on average per year [5]. In Israel, for desalination enterprises there is a table of electricity tariffs. Tariffs vary according to the seasons, days of the week and by the hour. The returned energy is 128,000,000 kWh per year costs 45 million shekels (=0.3545*128, 000,000).

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Funds from the sale of salt and returned energy to the network will be able to compensate for the costs of routine maintenance of all facilities and reimbursement of construction costs. In addition to 500 million m^3 of fresh water, we get a quasi lake with sea water with an area of 50 km^2. 140 million m^3 of water per year evaporates from the surface of this lake. The abundant, fresh, almost rainwater, so the living water, will allow for massive landscaping of this mountainous area and will breathe new life into the Dead Sea region.

Evaporative blocks are made of plastic materials. Metal is used only in valves, pumps and other equipment. Solar energy a wonderful gift of Nature, but the manufacture of equipment and the construction of roads and a network of pipelines will naturally require financial investments. . It is possible that for the recovery of the Dead Sea it is considered that it is enough to build the Complex with a capacity of only 200 ... 300 million cubic meters of fresh water. The above calculations for real design should be updated with account the current standards.

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