

A Process for Simultaneous Solar Distillation and Drip Irrigation

The availability of high-quality irrigation water is decreasing in many agricultural areas, while the volume of impaired water resources is increasing, due to irrigation drainage, industrial outflows, and sewage effluent. Most irrigated agricultural areas possess large amounts of land and ample sunshine during extended periods of the year. Solar distillation is a process that removes non-volatile impurities from water by separating water through evaporation and condensation (i.e., distillation) of water molecules, using sunlight as the source of energy for evaporation. Similar to irrigated agriculture, solar distillation requires large amounts of land and ample sunshine, suggesting opportunities for appropriate blending or coupling of solar distillation with irrigation. Coupling of the two processes may be facilitated by the positive correlation between solar radiation and both irrigation requirements and distillation production. Coupling of these processes may be of greatest potential value in irrigated agricultural areas where high-quality water is fully allocated, and/or the production of impaired water resources impacts the quality of the environment. Impaired water resources condition are increasingly common throughout the western United States, as well as many other semi-arid and arid regions of the world. This fact sheet describes a simple coupling of solar distillation with drip irrigation to supply purified water to row crops from impaired sources of water. The U.S. Geological Survey has been awarded a patent (U.S. Pat. No. 5,067,272) for the general process of simultaneous solar distillation drip irrigation (DDI). With appropriate field design and implementation, DDI has the potential of increasing the amount of water available for irrigation, while reducing the volume of impaired water within a surface-water and/or ground-water basin.

Figure 1 depicts a general visualization of



Figure 1: An artists conception of a row crop being irrigated with a DDI system. The specific sizing and placement of a system is dependent on cultural requirements.

DDI; however, a detailed realization can take on a variety of internal configurations. The general internal configuration is based on a large solar-absorbing surface area, which is either parallel to the ground surface or parallel to the slanted upper surface of the DDI system. Impaired source water is supplied at the upper end of an agricultural field planted to a row crop, such as a truck crop, vines, or a young orchard. In this figure, the ratio of plant surface to DDI surface is about 1 to 1; however, the appropriate ratio required to produce sufficient water depends on the crop and geographic location (Constantz, 1989). The source of impaired water can be salt water, saline or otherwise polluted ground-water, agricultural drainage, industrial or sewage effluent. (Source waters impaired with volatile liquids other than water, such as gasoline, would have to be stripped of these volatile compounds before they would be suitable source waters). The impaired source water flows through the DDI system, solar distillation

causes evaporation of water molecules, the molecules condense back to liquid on the upper surface of the system, the condensate is focused as it runs down the upper surface, and drips into the soil through the outer edges of the system as a line or point source, in a similar fashion to drip (trickle) irrigation.

There are various operational options for DDI. For example, a DDI system can be a flow through system or a batch system, in which the source water is either routed through the a DDI system from one side of the field to the other, or impounded within the inter-furrow area of the field until the end of the growing season. Other obvious options include solar-panel preheating of impaired water, and solar water pumps for acquiring and circulating (and/or re-circulating) impaired water through the DDI system at a flow rate that is governed by the incoming solar radiation. Figure 2 includes a schematic of the basic system with several operational options. The specific design and configuration of the DDI system within the

inter-furrow area can range from a simple clear plastic v-shaped tube overlying a flat black plastic solar absorber to a complex series of rigid v-shaped solar panels, coupled together the length of the inter-furrow area. Thus, lifetime and cost estimates of a DDI system are dependent on specific design and fabrication parameters. Regardless of parameters, a general advantageous feature of all DDI systems is the positive relationship between the current evaporative demand of the atmosphere above the field and the production rate of distilled water by the system installed within the field. This aids in sizing the system and reduces the potential for over irrigation, thus limiting adverse conditions, such as flushing of nutrients below the root zone or ground-water mounding.

A key factor in determining the commercial feasibility of DDI systems is predicting the performance of a system in a specific agricultural setting. This leads to estimates of the required size and cost of a system relative to the entire acreage requiring irrigation in this setting. The theoretical performance of a DDI system can be predicted using reported production rates of solar distillation systems under given atmospheric conditions versus reported irrigation requirements of various row crops under these same conditions. Based on this comparative technique, the DDI surface area required to product sufficient irrigation has been estimated for fives agricultural locations in the western US: Santa Maria (coastal southern) California, the Imperial and San Joaquin Valleys of California, Granite Springs Valley of central Nevada, and the southwest coast of Oahu, Hawaii. The sum of annual precipitation plus predicted DDI production over a range of surface areas compared with the predicted average (for several crops) annual irrigation requirement for these five locations, indicates that in general a DDI system covering half the total acreage is sufficient to meet the evapotranspiration demand of a crop which covers half the total acreage of the same field (i.e., the ratio of DDI to crop area depicted in Figure1). Additional factors can effect the required size of a DDI system, For example, the presence of a DDI system reduces bare-soil evaporation and thus irrigation requirements of a crop, while crop shading of a DDI system decreases the water production of the system. In the future, the general feasibility of DDI systems will grow with

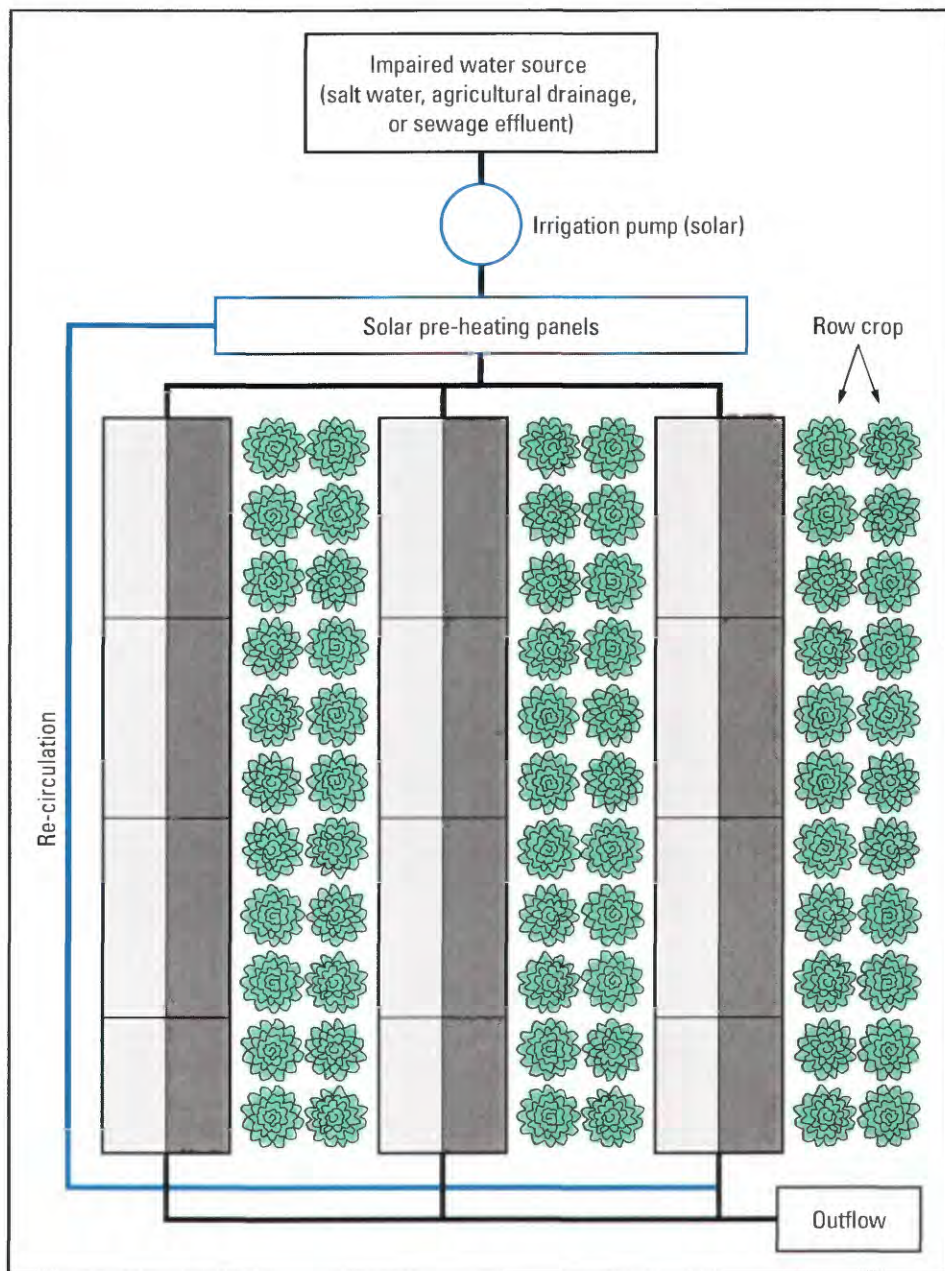


Figure 2: A schematic of the flow path for a DDI system. The portions of the diagram in black are basic elements of the path, while portions of the diagram in blue are some operational options.

scarcities of high-quality water and abundance of impaired water resources.

For More Information

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References

Constantz, J., 1989, Distillation irrigation: a low-energy process for coupling water purification with drip irrigation. *Agric. Water Manag.*, 15, 253-264.