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## CHAPTER 16

# ENERGY, WATER, FOOD FOR CITIES: DEPLOYING A POSITIVE TRIPLE NEXUS

Scholars are pointing to ways in which problems of energy security, water security, and food security interact, each exacerbating the effects of the others in what is called the Triple Nexus. But few examine the same issue from the perspective of the three fundamental drivers – energy, water, and food – systemically interacting to enhance and support each other’s contributions. In this text we are concerned not so much with the problems as with solutions. So turning things on their head, we can see how solutions to the individual power, water, and food problems might be able to reinforce each other so that solutions that are not economically or technologically feasible on their own *become feasible when considered together*. The way forward has already been identified in the form of proposals for combining production of power, water, and food in various ways that draw on renewable and replenishable resources.

In arid areas, for example, concentrated solar power and desalination systems can be developed that share a common heat-transfer fluid that is used both for desalination and for power production via concentrated solar power. The costs of each system taken on its own are considered uncompetitive, but if combined these costs are reduced so that the joint production of power and fresh water becomes feasible. Urban production of fresh produce such as vegetables can be reframed using specially designed greenhouses powered by renewable sources such as urban waste, turning cost disadvantages on their head. Clean food can thereby be produced from clean energy in a way that generates advantages over traditional horticultural methods. These are the clear directions of change in the evolution of the industrial system.

When an industrial ecological perspective is applied, the three problems are tackled simultaneously, thereby generating multiple synergies or shared benefits. I propose to call this *hydrosolar gardening*, which produces power, water, and fresh food

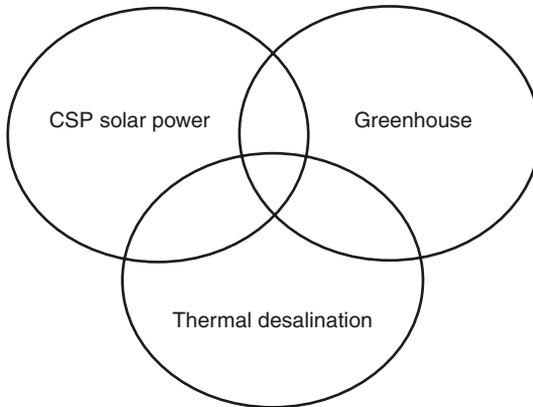
through joint production, with each activity supporting and enhancing the others. When you think of it, traditional agriculture can be called hydrosolar farming, since it depends on nature's inputs of sun and rain. But calling it gardening adds the element that it is farming within an enclosed, controlled environment. It can be applied at micro-scale at local level as well as at a macro-scale global level.

### **HYDROSOLAR GARDENS: SYSTEMIC INTERCONNECTIONS**

Let us call the interconnected production of food, fresh water and energy from renewable sources hydrosolar gardening. The fascination of the concept is that it liberates food production from the soil and the weather – and even from a fixed location. Hydrosolar gardens could be floating gardens on board a vessel that is moored in a convenient location – and which comes back to base once a month (say) for harvesting.

The core of the hydrosolar gardening system is the greenhouse, which receives inputs of fresh air and fresh water and heat from the ancillary systems. Nothing is supplied in the form of utilities other than a stand-by generator. The heat (for heating and cooling) is supplied from the storage tanks, where the fluid is held at a constant temperature, linked to the solar thermal system using (for example) parabolic mirror arrays and a pipeline containing the heated fluid. The water is supplied by the desalination unit, which would use heat and power generated from the solar system. The interconnected system can be depicted as shown in Figure 16.1.

**FIGURE 16.1.** Schematic of the Hydrosolar Garden system.



SOURCE: Author.

The hydrosolar garden consists of parts that individually are well tried and tested, but which in combination deliver new and undiscovered efficiencies, or synergies. This is the essence of the concept of a system, viewed as an integrated entity, where the whole is greater than the sum of the parts. There is already a commercial exemplar of this approach – the *Sundrop Farms* concept.

### SUNDROP FARMS

The Sundrop Farms model is a scalable and modular version of renewable farming that utilizes only clean and sustainable inputs. The first instance of the model, created at Port Augusta in South Australia, started full production in September 2016. The venture consists of four huge greenhouses, each 5 hectares in area, making a total of 20 hectare under cover in which trussed tomatoes are flourishing. The farm is producing tomatoes at a rate of 15,000 tons per year, all supplied to the national retail chain Coles, under a ten-year exclusive supply agreement.<sup>1</sup>

The power that runs the whole facility is supplied by a Power Tower system utilizing a field of mirrors, deploying Concentrated Solar Power (CSP) technology supplied by the Danish firm Aalborg CSP. The mirrors are computer-controlled to follow the sun, and reflect concentrated solar energy to the top of the tower, where water is heated and passed to both a huge storage tank and to a turbine system to generate electric power. Seawater is pumped in from the nearby Spencer Gulf and transformed to fresh water, at a rate of 450 million litres per year, using a Multiple Effect Distillation (MED) system. The MED water desalination process mimics nature in heating the seawater and capturing it as it condenses as fresh water – just as the water cycle uses evaporation from the sea to create rainclouds which then provide precipitation over land.

The fresh water is then pumped to the 20 hectare greenhouses, to provide the medium in which to grow the plants (initially tomatoes) enriched with nutrients. Because everything is so clean there is no need to use herbicides or pesticides or any other nasty chemicals. The few pests that are encountered are dealt with biologically, by introducing predators for any identified insects. In winter the plants are warmed by the heated water pumped to the heat tanks

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1. See details at: <http://2015.sustainability.wesfarmers.com.au/case-studies/environment/coles-enters-10-year-contract-for-tomatoes-powered-by-sun-and-seawater/>.

direct from the Power Tower. In summer the plants are cooled by another simple technology involving wet cardboard grills cooled by evaporation as seawater is pumped through them.

The whole farm is designed to be 100 per cent based on renewable energy and unlimited supplies of seawater. At the moment, in this very early phase, there is still some reserve pumping from diesel-powered generators – but it is planned to eliminate this remnant of the fossil fuels economy as soon as possible.

As a high-tech business venture, the project has been driven by accessing the best technology – advanced greenhouses, advanced hydroponics, CSP power system and MED desalination unit – as well as smart finance. The venture attracted early financing from Australia's Clean Energy Finance Corporation.<sup>2</sup> After the 10-year exclusive supply agreement was reached with the supermarket chain Coles (what could be called a 'production purchase agreement' or PPA, by analogy with comparable power purchase agreements for renewable power ventures), the global venture capital firm KKR was attracted and agreed to invest \$100 million. So the whole project is up and running with total investment of \$200 million – or \$10 million per greenhouse hectare.

The entrepreneur behind all this is Philipp Saumweber, a former merchant banker and graduate of Harvard Business School. He started out partnering with the founder of Seawater Greenhouse but quickly went his own way with high-tech CSP and MED technologies while Seawater Greenhouse insisted on staying at a low-tech level. He has designed Sundrop Farms as a modular and scalable solution to the global agricultural dilemma, where it is clear that expanding global population cannot possibly be fed by traditional methods, even with more and more fossil fuel inputs. Saumweber is talking up the possibility of extending the Sundrop Farms concept to other sites in Australia and to other parts of the world as well, such as the US (Tennessee) and Odemira in Portugal. China is the obvious candidate for the Sundrop farms approach to growing fruits, vegetables and berries – all at scale, in sustainable fashion, and near the burgeoning cities.

There are some limitations of course. The concept does not seem to be suitable for broad-acre farming of grains, which still remain a major sink for fossil fuel use and greenhouse gas emissions. And the concept is still not completely clean while the brine left after desalination is simply pumped back

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2. See details at: [https://www.cleanenergyfinancecorp.com.au/media/65410/cefc\\_factsheet\\_sundropfarms\\_lr.pdf](https://www.cleanenergyfinancecorp.com.au/media/65410/cefc_factsheet_sundropfarms_lr.pdf).

to the Spencer Gulf. This one farm is obviously not going to make a difference to the salinity of the Southern Ocean. But scaled up to a global level there could be concerns, and so 100 per cent recycling is obviously the eventual goal.

The essence of the Sundrop Farms System (SFS) is that it is modular, scalable and can be located anywhere in the world, with preference for arid coastal areas that would otherwise be quite unsuitable for any form of agriculture, let alone horticulture. It turns the two most abundant resources of the planet – sunlight and seawater – into food, energy and fresh water. There are literally no limits to its application.

### **WIDER ECONOMIC SIGNIFICANCE OF THE SUNDROP FARMS CONCEPT**

The idea of triple-benefit projects like Sundrop Farms comes into its own when scaled to the levels needed by China that is urbanizing as well as industrializing rapidly. From a basically rural country at the time of the Revolution, China achieved 20 per cent urbanization by 1980, then 30 per cent by 1996, 40 per cent by 2002 and 50 per cent (or majority city-based) by 2011. Over the decade from 2005 to 2015, China's urban population increased from 560 million to 770 million, or 210 million over the decade – meaning on average 21 million people moving to the cities each year. The task of providing adequate fresh food and water to these vast urban populations would appear to be insuperable without radical changes such as those suggested by the triple-benefit version of the triple nexus concept (or what I am calling hydrosolar gardening).

Sundrop Farms seen as an economic entity captures increasing returns as its output grows and sufficiently advanced customers (e.g., supermarket chains) can absorb its output. In this way Sundrop is replicating the same issues encountered by the Ford Motor Company as it invented the mass market for the automobile early in the twentieth century – a management challenge of finding adequate distribution outlets that was solved by the development of car dealerships as specialized retail outlets that could expand the market and operate at scale.

In effect Sundrop represents the application of mass market industrialization to the production of fresh food, utilizing manufactured components (greenhouse with irrigation and pumping systems; power generation and heat from the concentrated power system; desalination unit) that liberate production of food from environmental conditions (soil, weather, water). All the components interact with each other and produce synergies. Desalination plants or CSP plants on their own would not be economical in arid parts of the world, but when combined with greenhouse production of fresh food they become an

attractive proposition. Moreover the food is virtually pest-free because the environment in which it is grown is controlled (and the few pests that penetrate can be controlled biologically).

This is mass-market industrialization in a sustainable manner, where the inputs are the two most abundant resources on the planet – sunshine and seawater. There would appear to be no limits to the scalability of the SFS, which can be replicated around the world and can be broadened to encompass different vegetable crops and then beyond vegetables to seedlings and flowers (floriculture), and eventually to protein produce such as fish and seafood (via mariculture) or production of algae. In fact in principle all forms of nurtured living entities (fruits, berries, vegetables, flowers, seedlings, seafood) can be raised according to the principles of the SFS.<sup>3</sup>

Since the world's fresh water resources are under great stress, with irrigated agriculture taking up to 70 per cent of available resources (according to FAO), projects like the Sundrop Farms version of sustainably industrialized horticulture has vast promise. It promises not just clean food in virtually unlimited quantities but also great development potential for poor countries, since all the elements of the Sundrop farms module have to be manufactured and constructed – which can provide business opportunities for local entrepreneurs and employment for local, rural communities. And manufacturing activities are able to exploit improved productivities to capture increasing returns as markets for mass produced goods expand. By contrast, traditional agriculture with its dependence on soil and climate is subject to diminishing returns.

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3. Mention should also be made of the Sahara Forest Project, which likewise grew out of the Seawater Greenhouse concept, and is operating a quasi-commercial facility in Qatar.