Seawater Greenhouse

www.seawatergreenhouse.com

The Seawater Greenhouse

The continued growth of demand for water and increasing shortages of supply are two of the most certain and predictable scenarios of the 21st century. Agriculture, with a high demand for water, will be a major pressure point.

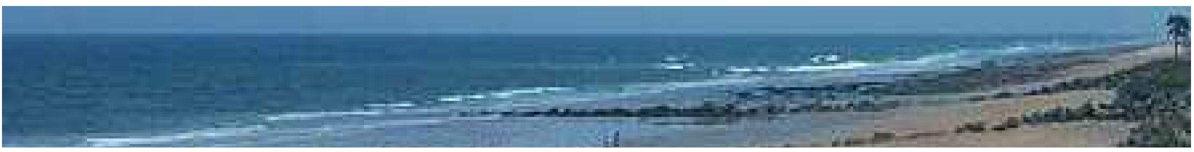
The Seawater Greenhouse will help to address this crucial problem in a cost-efficient and sustainable way, saving scarce water supplies for human and industrial use.

The Seawater Greenhouse is a unique concept which combines natural processes, simple construction techniques and mathematical computer modelling to provide a low-cost solution to one of the world's greatest needs – fresh water. The Seawater Greenhouse is a new development that offers sustainable solution to the problem of providing water for agriculture in arid, coastal regions. The process uses seawater to cool and humidify the air that ventilates the greenhouse and sunlight to distil fresh water from seawater. This enables the year round cultivation of high value crops that would otherwise be difficult or impossible to grow in hot, arid regions.

Population growth is threatening the availability of fresh water in many regions of the world. With agriculture accounting for approximately 70% of all water used, the water crisis is closely linked to food production and economic development. Conventional agriculture is very inefficient in its use of water with several hundred litres needed to produce just one kilogram of produce. Although seawater is abundant, conventional desalination consumes substantial energy, usually derived from fossil fuels. There is a need for affordable and sustainable means of producing food and water, without reliance on energy reserves.

Self-sufficiency in water production combined with low internal irrigation requirements mean that The Seawater Greenhouse offers significant water savings by reducing agricultural demands on mains and ground water. The Seawater Greenhouse solution has the potential to make a positive impact on the impending global water crisis. It may also become the lowest cost method of desalination and perhaps one of the few that is truly sustainable.

Today, the Seawater Greenhouse is ready for implementation in any arid region where a sustainable approach to agriculture and water production is needed.

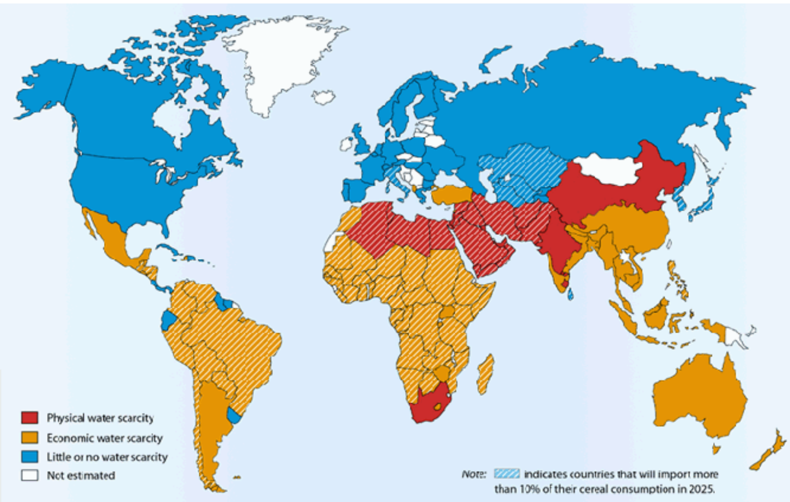


Meeting the Need

A shortage of water and the inability to grow food is the root cause of much suffering and poverty. Over a billion people do not have access to a safe supply of water and the number is growing. Large areas of the world already suffer from drought while deserts and populations increase in size. Rainfall remains broadly constant, yet demand for water has doubled in the last 20 years. As demand outstrips renewable supply, the depletion of ground water is accelerated. In coastal regions this causes saline intrusion which reduces the ability to grow crops and is now a major problem in many parts of the world.

Agriculture accounts for 70% of fresh water used globally. This percentage is often higher in regions that suffer from chronic water shortages. In the Middle East and North Africa, for example, up to 90% of available water is used in agriculture.

With the world water cycle roughly constant, the only source of sufficient fresh water to meet rising demand is the sea. No activity can take place without fresh water. The Seawater Greenhouse is an easily implemented process which offers a low-cost solution for the production of fresh water, and the cultivation of crops.



Countries marked with red and yellow will have various degrees of serious water scarcity in 2025 according to the International Water Management Institute's Global Water Scarcity Study in 2000. But already today we know that water scarcity is a problem in areas such as Sicily, Italy and Almaria, Spain.

Regions

Countries with areas of semi-arid to hyper-arid climates in proximity to the sea include:

EUROPE Balearic Islands, Canary Islands, Cyprus, Crete, France, Gibraltar, Greece Mainland & Islands, Italy, Malta, Portugal, Sardinia, Spain, Sicily.

NORTH AMERICA California, Cayman Islands, Mexico, Oregon.

MIDDLE EAST Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Palestine, Qatar, Saudi Arabia, Syria, UAE, Yemen.

LATIN AMERICA Argentina, Brazil, Chile, Colombia, Ecuador, Peru, Uruguay, Venezuela.

ASIA China, Indian Ocean Islands, India, Pakistan, Turkey, Sri-Lanka.

AFRICA Algeria, Angola, Cape Verde Islands, Djibouti, Eritrea, Ethiopia, Gambia, Kenya, Libya, Madagascar, Mauritania, Morocco & Western Sahara, Mozambique, Namibia, Senegal, Somalia, South Africa, Sudan, Tanzania, Tunisia.

AUSTRALIA Pacific Islands

From Concept to Reality

The Seawater Greenhouse project dates back to 1991 when the concept was first researched and developed by Light Works Ltd. The first pilot project commenced in 1992 with the search for a test site which was eventually found on the Canary Island of Tenerife, once known as the 'Garden of the Gods', but now arid and seriously damaged by excessive abstraction of ground water.

A prototype Seawater Greenhouse was assembled in the UK and constructed on the site in Tenerife. The results from this pilot project validated the concept and demonstrated the potential for other arid regions.

The original pilot design has now evolved into a more elegant yet lower cost solution using a light but strong steel structure similar to a multi-span polytunnel. This structure is designed to be cost-effective and suitable for local sourcing. This design was first tested and validated through a second Seawater Greenhouse that was constructed on Al-Aryam Island, Abu Dhabi, United Arab Emirates in 2000. In both cases, crop production in terms of quality and quantity has been outstanding, with the Greenhouse supplying in excess of the water required for irrigation.

2004 saw the completion of a second pilot Seawater Greenhouse near Muscat, Oman. In collaboration with Sultan Qaboos University, this exciting project will provide an opportunity to develop a sustainable horticultural sector on the Batinah coast. It will help reclaim abandoned agricultural land where soil and water salinity have reached levels at which crop production is not viable.

These projects have enabled the validation of a thermodynamic simulation model which given appropriate meteorological data, accurately predicts and quantifies how the Seawater Greenhouse will perform in other parts of the world.

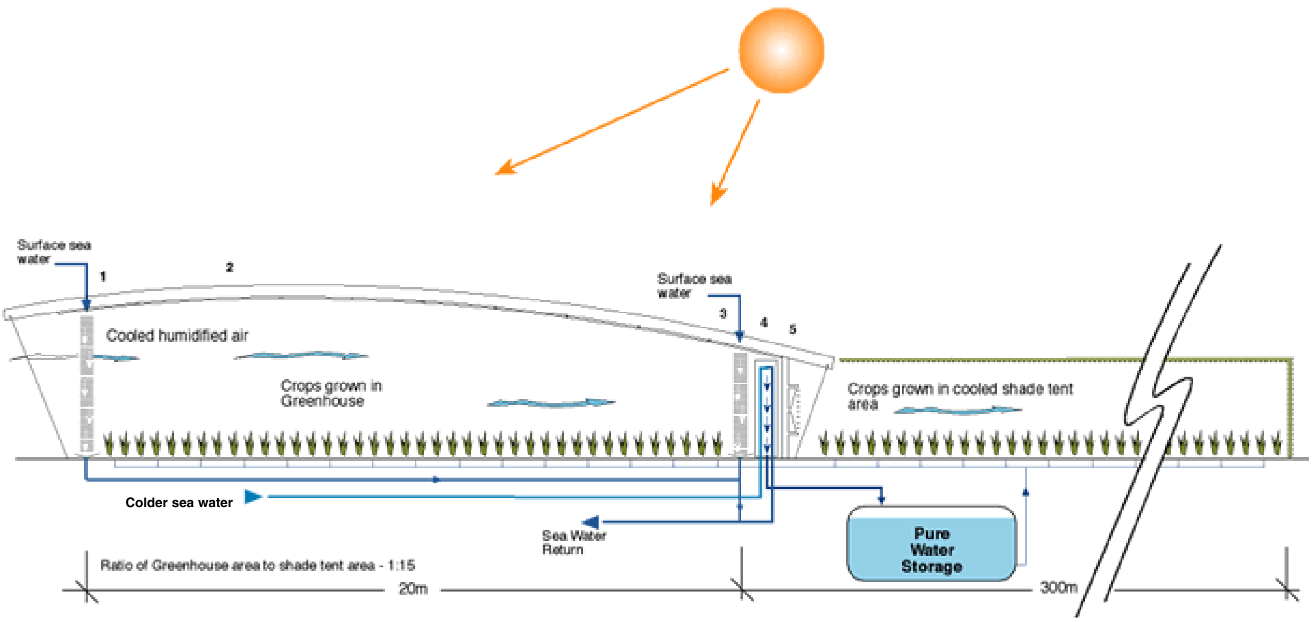
The Process

The Seawater Greenhouse uses the sun, the sea and the atmosphere to produce fresh water and cool air. The process recreates the natural hydrological cycle within a controlled environment. The entire front wall of the building is a seawater evaporator. It consists of a honeycomb lattice and faces the prevailing wind. Fans assist and control air movement. Seawater trickles down over the lattice, cooling and humidifying the air passing through into the planting area.

Sunlight is filtered through a specially constructed roof, The roof traps infrared heat, while allowing visible light through to promote photosynthesis. This creates optimum growing conditions – cool and humid with high light intensity.

Cool air passes through the planting area and then combines with hot dry air from the roof cavity. The mixture passes through a second sea water evaporator creating hot saturated air which then flows through a condenser.

The condenser is cooled by incoming seawater. The temperature difference causes fresh water to condense out of the air stream. The volume of fresh water is determined by air temperature, relative humidity, solar radiation and the airflow rate. These conditions can be replicated in the thermodynamic model and, with appropriate meteorological information, the detailed design and performance of the Seawater Greenhouse can be optimised for every suitable location and environment.



1 Surface sea water trickles down the front wall evaporator through which air is drawn into the Greenhouse. Dust, salt, spray, pollen and insects are trapped and filtered out, leaving the air pure, humidified and cool.

2 Sunlight is selectively filtered by the roof elements to remove radiation that does not contribute to photosynthesis. This helps keep the Greenhouse cool whilst allowing the crops to grow in high light conditions.

3 Air passes through a second seawater evaporator and is further humidified to saturation point.

4 Saturated air passes through the condenser which is cooled using colder sea water. Pure distilled water condenses and is piped to storage.

5 Fans draw air through the Greenhouse and into the shade hosue area.

Water Production and Water Savings

The Seawater Greenhouse converts sea water into fresh water, providing a unique local desalination capability. The water is condensed from water vapour in the air, in much the same way as dew. It is pure distilled water, produced without chemical treatment. The quantity produced depends on the climate – the hotter and sunnier, the more water.

The air entering the Greenhouse is both cooled and humidified. High humidity and low temperatures (the Greenhouse operates at approx. 90% relative humidity) reduces plant transpiration substantially, by up to 80%. This reduces irrigation requirements. The irrigation rate in Tenerife averaged 1.2 litre/day/m^2 against 8 litres/day/m^2 used by local farmers.

The impact of a new source of water on a local area can be highly beneficial. In Tenerife, a barren area 'turned green' as seepage from irrigation reversed saline intrusion and enabled new plant growth.

Of even greater importance is the effect the Seawater Greenhouse can have on reducing demand for mains water and reserves of ground water. Around 8-10 litres per m^2 per day can be saved which, on a macro scale, will have an immense impact, freeing existing water supply for other uses.

What others say

Johan Perret of the Sultan Qaboos University's soil and water engineering plant, Oman: "The concept is a very promising alternative way of generating fresh water in Oman, both for coastal regions and inland, where we have brackish under ground water. Farms are literally dying and it will allow us to reclaim the abandoned land."

Construction and Materials

The Seawater Greenhouse has a specific function – to produce fresh water and cool air while allowing maximum light penetration. The choice of materials is guided by the level of performance required – and cost. Various specifications of Seawater Greenhouse are available.

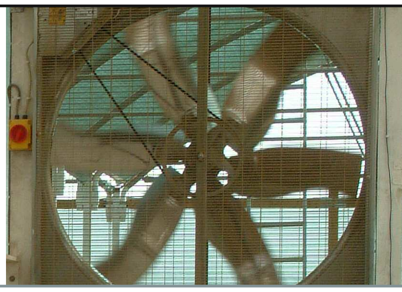
Low-cost solutions give excellent results. The design requires a light steel structure with polythene covering, cardboard evaporators and a plastic condenser. ABS and MDPE plastics are used for plumbing. Polythene films are cheap and effective. They are specially treated to incorporate ultraviolet-reflecting and infrared-absorbing properties and can be 100% recycled at the end of their useful life.

The cardboard evaporators are strengthened by a surprisingly effective process. They crystallise calcium carbonate from the sea water and harden like sea shells. The process is controllable and the results indicate that the life of the evaporators can be extended almost indefinitely.

The normal procedure for a new market is the provision of a 'starter pack' of components for the first structure, with the options of continued supply or investigation of a local sourcing programme for subsequent structures.

Our policy is geared to local sourcing and the provision of the working structure at the lowest possible cost. The structure can be erected quickly and relatively inexpensively and many of the required components are widely available. Design and commissioning is carried out by the Seawater Greenhouse team.

Energy Requirements



The Greenhouse is driven by solar and wind energy. Sunlight is separated into visible and infrared light. Visible light passes through the roof to drive photosynthesis. Infrared light is trapped in the roof canopy and is ducted from there to the seawater evaporator. Thus solar energy converts seawater to water vapour.

The structure acts as a 'wind-catcher'. It faces into the prevailing daytime wind to assist ventilation. Fans are required under most conditions although these were unnecessary in Tenerife. The wind-fan combination moves air through the front evaporator and chills the sea water which then provides cooling for the rear condenser and, thus, the production of fresh water.

The electricity requirements are modest and, in the absence of grid power, can be provided by photovoltaic panels without the need for batteries, inverter or standby generator. The Tenerife Greenhouse was built on a wind farm with power supplied by the wind turbines on site. There are thus potential synergies between the Seawater Greenhouse and both wind and solar power.

The overall process is extremely energy efficient. 1kW of electricity expended on pumping will remove 500kW of heat. Water can be produced at low energy costs (<3kWh/m^3).

What others say

Marco Goldschmied, president of the Royal Institute of British Architects, in 2000 called the Seawater Greenhouse "a truly original idea which has the potential to impact on the lives of millions of people living in coastal water-starved areas around the world".

Sustainable Design and Development

Commercial greenhouses have demanding criteria. The realities of horticultural economics require low capital costs and low running costs, also durability and adaptability to the climate. The Seawater Greenhouse fulfills these demands, sustainably. The design approach centres on close observation of how natural processes interact – evaporation and condensation, the effects of light and heat on photosynthesis and the influence of airflow. While these phenomena are well understood, when combined and fluctuating over time, they paint a complex and intriguing picture.

The Seawater Greenhouse design, which originated as a largely intuitive concept, has been refined by scientific and materials knowledge, gained through testing and modelling, and validated by results. The thermodynamic model, in which the physics of the process have been incorporated, gives us a better understanding of these issues. The model allows the testing of design concepts and the development of optimum solutions through iterative simulations for any given set of climatic conditions and commercial objectives.

Constant improvement

Seawater Greenhouse Ltd maintains a policy of continuous innovation and development. Dr Philip Davies has recently been awarded a Royal Society Industry Fellowship, based at the University of Warwick that will improve the design of the Seawater Greenhouse and help lead to its widespread use.

There are three principal objectives to his study:

- The use of computational fluid dynamic modelling to gain a better understanding of the air flow in the Greenhouse and minimise the power required for fans.
- To reduce transpiration further by the filtration and attenuation of sunlight and refining the new low cost Watermaker condenser to increase the amount of freshwater produced.
- A survey of renewable energy technologies to find appropriate solutions that enable the greenhouse to operate in a truly 'stand-alone' configuration.
- Data collected from the Oman project will be compared to modelling results to validate them and then applied to future projects.

Economics and Applications

The economics of Seawater Greenhouse operations depend on the profit margins of the crops produced and the volume and use of surplus water. These in turn depend on a range of local conditions which vary from one region to another. The establishment of additional growing areas outside under shade and using the surplus water can increase the total cultivated area and reduce the overall capital cost per m^2 of cultivated land.

Operating costs are low in regions with abundant sunshine. It is substantially cheaper to cool and humidify a Seawater Greenhouse than to provide supplementary heat and light to a glasshouse in say Northern Europe.

Capital costs depend on the choice and style of the desired greenhouse and local sourcing is encouraged to keep costs to a minimum. One of the most economical solutions is a polythene-clad steel framed multi-spanned greenhouse, which are very common in the horticultural world. If you have a particular project in mind, please contact us to discuss your ideas and requirements. Prices and costs are given by individual quotation as local conditions and in particular the required specifications vary.

Contact information

To discuss the opportunities further, contact:

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