



Enabling Restorative Growth

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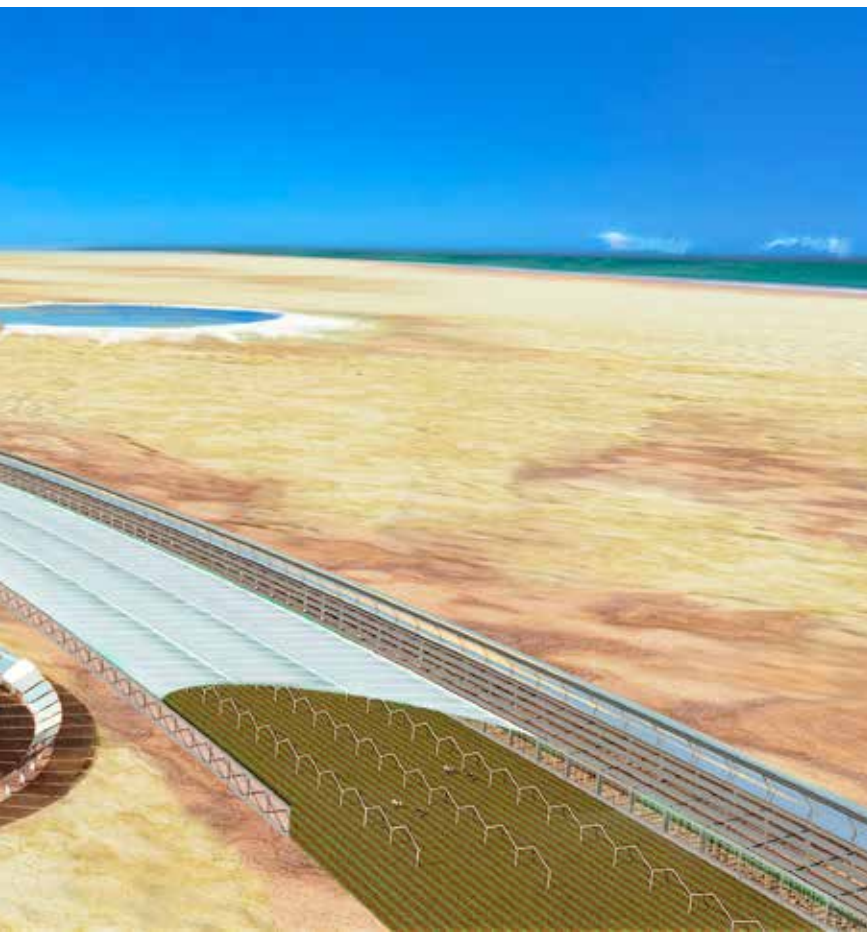
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# FROM VISION TO REALITY



The Sahara Forest Project vision



In 2050 about 9.3 billion people will share our planet. Already today the world is facing intertwined challenges of food, water and energy security, coupled with climate change, desertification and shrinking forests.

None of these challenges are without solutions. At the same time it is ever clearer that we cannot afford to pursue responses to one challenge that come at the expense of another. The greatest challenges of our time are closely interlinked and the same must be true for their answers.

The Sahara Forest Project has been established to realize a vision of

**Restorative Growth:**

“Revegetation and creation of green jobs through profitable production of food, freshwater, biofuels and electricity”

# CONCEPT

The Sahara Forest Project has set out to establish groups of interconnected economic activities in low lying desert areas around the world.

The simple core of the concept is an infrastructure for bringing saltwater inland. Through establishing this saltwater infrastructure The Sahara Forest Project aims to:

- make electricity generation from solar power more efficient
- operate energy- and water-efficient Saltwater-cooled greenhouses for growing high value crops in the desert
- produce freshwater for irrigation or drinking
- safely manage brine
- grow biomass for energy purposes without competing with food cultivation
- revegetate desert lands

The synergies arising from integrating the technologies improve performance and

economics compared to those of the individual components. In addition to its commodity outputs of food, energy and salt, the system also provides global climate benefits by sequestering CO<sub>2</sub> in the facility's plants and soils. The technological combination in The Sahara Forest Project is designed to utilize what we have enough of to produce what we need more of, using deserts, saltwater and CO<sub>2</sub> to produce food, freshwater and energy.

The Sahara Forest Project has been developed through a step-by-step process of concept and feasibility studies, data modelling, field trials, pilot operations, R&D programs and value engineering.





The experience and knowledge from The Sahara Forest Project **pilot facility** in Qatar is a key resource for further development in Jordan.



The Saltwater-cooled greenhouses are highly productive in desert areas.

## SALTWATER-COOLED GREENHOUSES

Saltwater-cooled greenhouses utilize saltwater to provide suitable growing conditions for year-round cultivation of high-value vegetable crops in hot and arid environments. The saltwater is run down honey-combed cardboard pads at one end of the greenhouse, while solar-powered fans draw hot desert air through them and into the greenhouse. As the saltwater evaporates into the hot air, the air becomes cooler and more humid, creating a growing environment inside the greenhouse well-suited for the cultivation of vegetable crops. By using saltwater to provide evaporative cooling and humidification, the crops' water requirements are minimized and yields maximized with a minimal carbon footprint.

Data from The Sahara Forest Project pilot operations in Qatar has demonstrated:

- The yields obtained in the pilot stage are competitive with that of leading European greenhouse operations with 75 kg of cucumbers per m<sup>2</sup> a year.
- The greenhouse achieved up to 15 degrees cooling in summer.
- The water usage is half of comparable greenhouses in the region.
- The Saltwater-cooled greenhouse allows for year-round production of high quality crops, even in periods with very high outside temperatures.





Concentrated Solar Power (CSP) in a Sahara Forest Project system allows for efficient production of renewable energy.

## SOLAR TECHNOLOGIES

The Sahara Forest Project (SFP) utilizes solar power technologies to provide power for electrical installations in the SFP-facility, while the majority of the power can be exported from the facility.

The solar power technologies convert sunlight into electricity, either directly using Photovoltaics (PV), or indirectly using Concentrated Solar Power (CSP) to provide electricity and heat generation. Both PV-systems and CSP-systems benefit from the integration with other SFP-technologies.

Dust arresting from the surrounding vegetation, and water for cleaning the PV-panels and CSP-mirrors ensure efficient electricity generation. The Concentrated Solar Power facility will also benefit because the greenhouses and hedges can provide efficient water-cooling with saltwater. This means that freshwater is not wasted and that construction of cooling towers is avoided. Through Pilot Facility operations it has been verified that synergies of CSP with other SFP technologies can provide wet-cooling efficiencies for power generation, or desalination, without cooling towers.



The external evaporative hedges provide significant cooling and humidification, beneficial for food and fodder crops in addition to a wide range of desert species.

## REVEGETATION

Desert revegetation is catalysed by creating humid growing spaces outside in the desert using the same principles of evaporative cooling at play in the Saltwater-cooled greenhouses. Brine – the waste product of saltwater used in the cooling and distillation process in the greenhouses – is evaporated over ‘hedges’ to create sheltered and humidified cultivation areas, which host both native desert species and water-efficient food and fodder crops. Nitrogen-fixing and salt-removing desert plants can be deployed in concert with repurposed waste products from agriculture and saltwater evaporation to improve soil conditions, boost crop yields, and reduce requirements for mineral fertilisers. In contrast to most traditional desalination practices, The Sahara Forest Project has the potential to operate without discharge of brine back to the sea.

At the Pilot facility in Qatar 19 desert plants and vegetable and grain crops were successfully cultivated outdoors in the desert throughout the year. Many of the native desert species has exciting potentials as new sources of fodder and bioenergy or for the purpose of carbon sequestration and soil conditioning.



The Sahara Forest Project can enable commercial-scale cultivation of algae in new regions of the world.



The Sahara Forest Project produces freshwater for irrigation or drinking from saltwater.

## EXTENSIONS

By establishing a commercially viable way to bring saltwater into the desert, The Sahara Forest Project works as an enabling technology, creating opportunities for a wide range of businesses to develop alongside it.

These opportunities include salt extraction, traditional desalination, algae production, halophyte cultivation, mariculture, bioenergy and more. The Pilot Facility in Qatar included state-of-the-art facility for cultivation of microalgae, evaporation ponds for salt production and a facility for cultivation of salt-tolerant plants (halophytes).

# JORDAN

The Sahara Forest Project was first presented to His Majesty King Abdullah II of Jordan in 2010. In 2011, a Memorandum of Understanding was signed between the Aqaba Special Economic Zone Authority and The Sahara Forest Project in Amman, Jordan. The agreement committed The Sahara Forest Project to conduct a set of comprehensive Feasibility Studies in Jordan. The studies were financed and supported by The Norwegian Ministry of Foreign Affairs.

The Feasibility Studies was conducted with the involvement of more than 60 scientists and experts from 12 different countries. In the presence of HRH Crown Prince Haakon of Norway and the Jordanian Minister of Environment, HE Yaseen Khayyat, The Sahara Forest Project presented the results of the Feasibility Studies for Jordan in 2012. The studies demonstrated a clear

potential for a full commercial rollout and large-scale production of food and energy, and how The Sahara Forest Project concept can contribute to economic development in Jordan.

Based on the Feasibility Studies The Sahara Forest Project put forward a proposal for a Sahara Forest Project Centre to be established in Aqaba, Jordan.



The Sahara Forest Project Jordan seminar in 2012. From left: Norwegian State Secretary for Foreign Affairs HE Gry Larsen, Jordanian Minister of Environment HE Yaseen Khayyat and HRH Crown Prince Haakon of Norway.



## LAUNCH STATION

On the 22nd of July 2014 The Sahara Forest Project signed an agreement with The Royal Norwegian Embassy in Amman for establishing a Sahara Forest Project Launch Station and related activities in Jordan. Funding is provided by the Norwegian Ministry of Climate and Environment, represented by the Royal Norwegian Embassy in Amman together with The Grieg Foundation and other philanthropic sources.

The Launch Station will be the first step towards the realization of a full-scale Sahara Forest Project Centre in Aqaba. The objective of this first phase is to demonstrate the technology under local conditions in Jordan, to engage a team on the ground and attract relevant stakeholders for going forward.

The Launch Station will contain a Saltwater-cooled greenhouse in combination with solar power technologies and facilities for outdoor cultivation and revegetation.



# THE JORDAN CENTRE

The Jordan Centre will be located in Aqaba, which offers excellent climatic and topographic conditions suited to the technological system of The Sahara Forest Project. The facility will contain all the core technological components of The Sahara Forest Project in a synergetic set-up and produce food and clean energy at a significant scale. The size of the facility will be approximately 20 hectares, designed to allow for easy later-stage expansion of the commercial operations. The Jordan Centre will also function as a shared R&D, innovation and training platform. Infrastructure and space will

be provided for the testing and integration of environmental technology components at the intersection of SFP's saltwater infrastructure and core technologies. By bringing together local and international entrepreneurs, scientists, business and other key players in green innovation The Jordan Centre will be a platform for research, innovation and training. The activities will be focused at delivering sustainable solutions to food, water and energy challenges.

The Jordan Centre will provide a commercial-scale demonstration of the full Sahara Forest Project value chain.

# SUSTAINABLE VALUE CREATION

Many of the technologies in The Sahara Forest Project are in commercial operation around the world in stand-alone facilities. Through integration of these technologies in a synergistic system waste streams are turned to resource streams and new economic opportunities arise.







The Sahara Forest Project is set up to utilize abundant land and plentiful renewable resources with its technological system in markets where demand is high for the products it creates. The Sahara Forest Project has gone through the stages of concept development, feasibility studies, data modelling, field trials and pilot operations with results confirming the financial soundness of the concept.

Today, The Sahara Forest Project is positioned to deliver:

- Increased cost effectiveness of solar energy production, both for its own use and for large scale export to the grid. Synergies of Concentrated Solar Power with other SFP technologies can provide wet-cooling efficiencies for power generation or desalination without cooling towers.
- Profitable large scale greenhouse production based on saltwater cooling and renewable energy. High quality and efficient production can be realized throughout the year with half the fresh water usage than in comparable greenhouses in hot, arid regions.
- A near-term, cost effective approach for production of biomass and revegetation in arid areas.



The Sahara Forest Project is established as two entities, a foundation and a private limited company.

### **Sahara Forest Project Foundation**

The Sahara Forest Project Foundation facilitates and promotes research, knowledge and the use of technologies for revegetation and the creation of new jobs through profitable production of food, water, biomass and electricity. The Sahara Forest Project Foundation acts as an incubator for launching new initiatives to realize the concept of Restorative Growth. The Foundation manages the Ethical Guidelines and Registered Trademark of The Sahara Forest Project.

### **Sahara Forest Project Company**

The Sahara Forest Project AS is a private limited liability company delivering profitable and innovative environmental solutions within the food, water and energy sector. This is achieved by bringing The Sahara Forest Project to market through delivery of competence, facility realization and operation in relevant countries. The Sahara Forest Project AS consists of an experienced international team with professionals in the fields of design and architecture, life sciences, agricultural engineering, growing techniques and business development. The team has developed a track record for delivering ground breaking ideas as concrete operations on the ground.

The Sahara Forest Project AS operates under the Ethical Guidelines set out by The Sahara Forest Project Foundation.



GRIEG FOUNDATION



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CLIMATE AND ENVIRONMENT**

## JORDAN PARTNERS

The Sahara Forest Project is interacting with a large number of experts, institutions and companies all over the world. This network is very important to us. Our Jordan Partners consist of entities providing both financial resources and know-how to The Sahara Forest Project. They have provided especially important contributions to establishing The Sahara Forest Project in Jordan.

"This is a gold standard in a day and age where we have a hot and crowded planet, and we need to move towards a low-carbon future fast." - **Olav Kjørven**, Assistant Secretary-General of the United Nations Development Program.

"The Sahara Forest Project appears to be a very interesting example of the more integrated and holistic kind of thinking that we will need a lot more of in the future to make our energy, water and industrial systems more sustainable."

- **Andris Piebalgs**, EU Energy Commissioner. "The Sahara Forest Project raises the important point that new renewable technologies and smarter environmental solutions can help both social, environmental as economic challenges."

- **Malek Kabariti**, Minister of Energy and Mineral Resources of Jordan. "This Pilot Project could show how we can grow vegetables with less water or brackish water. I think this will not be important only to Qatar, but to the whole region and elsewhere where they have the same climate as Qatar. So, I have a lot of hope."

- **Sheikh Hamad bin Jassim bin Jaber Al Thani**, Prime Minister of Qatar. "This is an example of the need for new and environmental friendly technologies to contribute to both increase the global production of food, but at the same time reduce the global emissions of greenhouse gasses."

- **Jens Stoltenberg**, Prime Minister of Norway. "Individually, the various technologies are commercially proved, but excitement stems from using them together for the first time."

- **Financial Times**. "A novel combination of technologies that has the potential to turn large areas of desert green, producing commercial quantities of food and energy crops, fresh water, and electricity" - **Science**. "Agriculture uses more than two-thirds of Earth's fresh water, so the idea of a farming practice that produces more water and energy than it consumes seems too good to be true. But in the desert of Qatar, scientists are showing that saltwater and sunlight can yield food and clean water in a self-sustaining cycle."

- **Nature**. "Sahara Forest Project is an ambitious attempt to use concentrated solar power and Saltwater-cooled greenhouses to produce renewable energy, crops and water. Its success thus far has inspired new feasibility studies in Jordan and Qatar." - **The Economist**. "SFP is a pioneering project that reflects the kind of holistic vision and solution that we need to explore so that we can address the interconnected challenges of food, water and energy security. It is about optimizing the whole system rather than maximizing one goal."

- **Dr. Dan Kammen**, Chief Technical Specialist for Renewable Energy and Energy Efficiency, The World Bank