Public Private Partnership on Water- Lessons from RAMDAS project on Solar Desalination

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Abstract: *There is a wide interest in Solar Energy utilization in India, a tropical country with an average solar insolation of 600 W/m*^{2}*. The acute shortage for domestic as well as industrial water in many coastal regions has resulted in the search for alternative methods for desalination. Due to increase in agricultural and industrial water requirements, the demand for water is projected to double by the year 2025. A solar energy driven multi-effect distillation (MED) project, with bio-mass boiler steam support for non-sunshine hours, for generating 6 m*^{3}*/hr has been developed by Empereal-KGDS Renewable Energy Pvt Ltd, Coimbatore with technical support from National Institute of Ocean Technology, Chennai, SWS & GB Saline Water Specialists Pvt Ltd, Trichi, and Tamil Nadu Water and Drainage Board. The project has been funded and guided by the Department of Science and Technology (DST) Govt. of India. Indian Institute of Technology Madras (IIT M) facilitated to carry out the fundamental research on falling film evaporation.*

Linear Fresnel Reflecting (LFR) solar thermal system was used to concentrate solar energy on a receiver where steam was generated at 21 bar and stored in an accumulator. The steady flow of steam was supplied to thermo-vapor compressor at a pressure of 5 bar through a pressure reducing valve. The discharge steam is supplied to a 6-effect MED system consists of evaporators, final condenser, vacuum condenser and pre-heaters. The complete system was designed, fabricated, integrated and commissioned at Ramanathapuram district in southern Tamil Nadu during 2010-12. The water quality produced caters to the multiple applications of distilled water as well as local drinking water requirement and paves the way for sustainable drinking water solutions. This project called RAMDAS has been a successful model of the inter-institutional collaboration and public private participation for development projects to meet the water requirement in the country. This paper presents the technical and social challenges, and lessons learned.

Keywords: *Solar Desalination, Water Scarcity, Private Public Partnership, Water Production and Management*

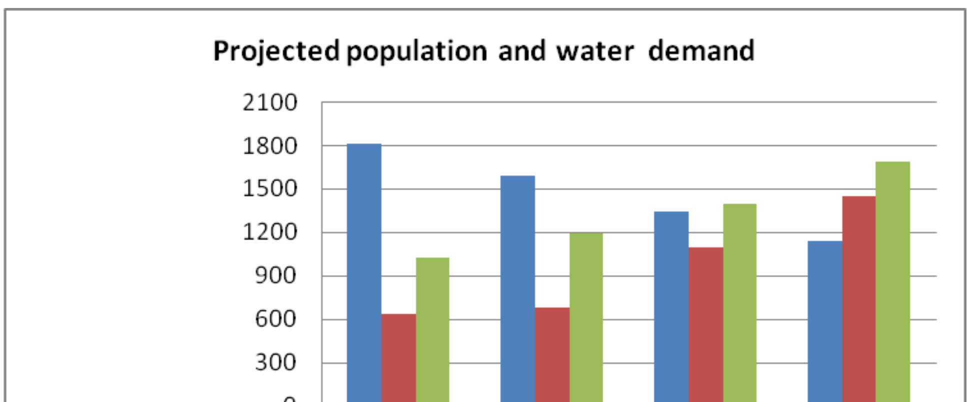
1. Introduction

Water is no longer considered as a free gift from God to mankind and has become the single most important factor responsible for the present problems worldwide. Many parts of the world suffer from acute water shortage due to reduced availability coupled with factors like population and industrial growth, changes in life-style, climate changes, urbanization, water pollution etc. India with 17% of the world population has only 4% fresh water sources and per capita water availability has reduced from 1816 m^3/year in 2001 by 15% in next 10 years. There is a great need for developing technologies for water, considering socio-economic factors. But the most difficult challenge is to make it acceptable, affordable and satisfying the local environmental requirements. Government agencies, R&D institutions and Industries need to be collaborated to meet the technical, economic and social challenges for the water requirements. This paper discusses on the inter-institutional collaboration for the solar desalination project named as RAMDAS commissioned during Jan-March 2013 at Ramanatahapuram, South Tamil Nadu.

2. Application of Solar Energy in Desalination Technologies

The commercial desalination technologies can be divided into two main categories: thermal desalination and membrane separation processes. Although many different technologies for seawater desalination have evolved over the years, there are three processes that have demonstrated global commercial success. These processes are Multi-Stage Flash (MSF), Multi-Effect Distillation (MED) and Reverse Osmosis (RO). In combination with solar heat source, thermal desalination technologies can be directly taken for utilizing the solar steam. The MSF process makes use of thermal energy for flashing of vapor where solar energy can be used as a source for heating water. In MED, steam generated by solar energy can be used for thin film convective evaporation of sea water. Both the process consists of a number of stages in which evaporation and condensation takes place. In the process of coupling with solar thermal system and Thermo-Vapor Compressor (TVC), MED technology is found to be optimum for solar-desalination process. In RO process the pre-heating of feed water using solar energy can improve the efficiency.

Desalination has become an inevitable option in many parts of the world. Figure 1 shows the reducing water availability and growing demand in India. Rapid urbanization and economic growth coupled with pollution produces ‘thirsty’ cities [1]. Most of the population centers are near the seacoast and many parts of the country get good shine. Utilization of solar energy for sea water desalination is an important technical option with its limitations of operating on non-sunshine hours and monsoon periods.



	2000	2010	2025	2050
Per capita water availabilty (m3/year/person)	1816	1588	1340	1140
Water demand(km3/year)	634	681	1093	1450
Population in India (million)	1027	1196	1400	1690

Fig. 1 Pojection of population, water avalaiabilty and demand until 2050.

Department of Science and Technology (DST) under the thrust area Solar Mission supported the research and developmental project on design, fabrication, testing and installation of 6 m^3/hr solar multi-effect distillation system for providing water in arid rural areas in Sept 2010 at the cost of Rs. 687.68 lakhs. The plant has been successful commissioned in February 2013 .

2.1. Principles of operation

The Linear Fresnel Reflecting (LFR) system uses a single axis tracking system which reflects the sunlight from the elastically curved mirrors on to a receiver positioned at about 12 m height where water is circulated. Saturated steam is generated with 40 to 80 % dryness in the absorber tubes at a pressure of 21 bar and temperature 215 °C. This steam is passed to the steam drum where saturated steam is separated from saturated liquid. The saturated water in the steam drum is fed back to the LFR field by recirculation pump and the saturated steam is taken to the steam accumulator. Steam enters the accumulator and gets condensed into the existing water. Steam is withdrawn from the accumulator at a pressure of 5 bar with the help of pressure reducing valve and is acting as the motive steam for the thermo-vapor compressor (TVC). The steam from the solar field or bio mass boiler is discharged by TVC at 0.245 bar pressure and 91 °C temperature. This steam is fed to the 6 effect MED unit where it is initially de-superheated to 65°C and then fed to the effect 1. As the steam condensed in the first effect tubes, it exchanges heat to the falling film of sea water outside the tubes causing evaporation of seawater. The evaporated vapor is supplied to the second effect and it is condensed while exchanging heat with the film outside the tubes in second effect. The process is repeated in all the 6 effects to produce the distillate at about 2 ppm quality [2].

2.2. Water Policy and Collaborative Agencies

RAMDAS was the development project with technical and financial co-operation of the government with private participation. Empereal-KGDS Renewable Energy Pvt Ltd, Coimbatore with technical support from National Institute of Ocean Technology, Chennai, SWS & GB Saline Water Specialists Pvt Ltd, Trichi, and Tamil Nadu Water and Drainage Board (TWADB) coordinated the project activities. IITM facilitated to carry out the research on falling film evaporation. The agencies collaborated in the work with the responsibilities shown in Fig.2.

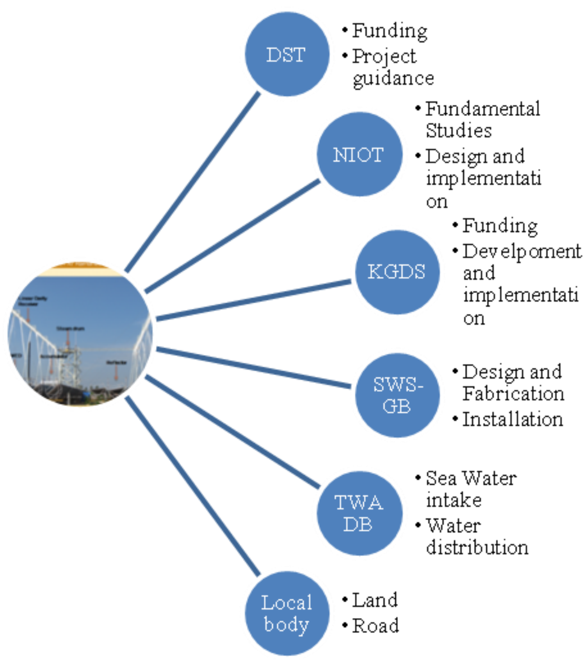


Fig. 2 Collaborating agencies for RAMDAS project on Solar Desalination

3. Site Selection

The complete system was designed, fabricated and installed at the coastal village of Narippeiyur, Ramanathapuram district in Southern Tamil Nadu. The area has an average solar insolation of 600 W/m^2 and of peak value 850 W/m^2. The location is a drought zone and is lacking drinking water in most of the months in a year. An RO plant of 160 m^3/hr capacity was functioning in the same location for nearly 15 years and partially meeting the water requirements. The plant was operated by TWAD board and distribution system exists to the nearby villages. The region has plenty of bio mass available for boiler operation for night hours. The surface sea water is drawn from the existing sump of the RO plant at the rate of 40 m^3/hr and reject water with additional 10% ppm is mixed with the RO plant discharge. The location was selected after a complete survey of many coastal villages due to existing infrastructure facilities such as road, electricity, water distribution system etc. Also the existing intake system with a capacity of 500 m^3/hr could avoid the construction of a new sea water intake system and associated clearances.

4. Implementation of the Project

The project was being monitored by technical committees at regular interval and finally the civil work at site was started on 2nd Oct 2011 in august presence of Dr. T. Ramasamy Secretary DST and other diginataries. The Solar field, Bio mass boiler, MED system, Remineralisation Unit, Fresh water storage system etc. was installed at specified locations close to the shore. Seawater inlet and discharge lines were laid. The feedback and control loops of the system started in November 2012 and being perfected by February 2013. Simultaneous operation of the solar and bio-mass system was done with switching over from one system to another. Fig. 3 shows the arrangement of the plant.

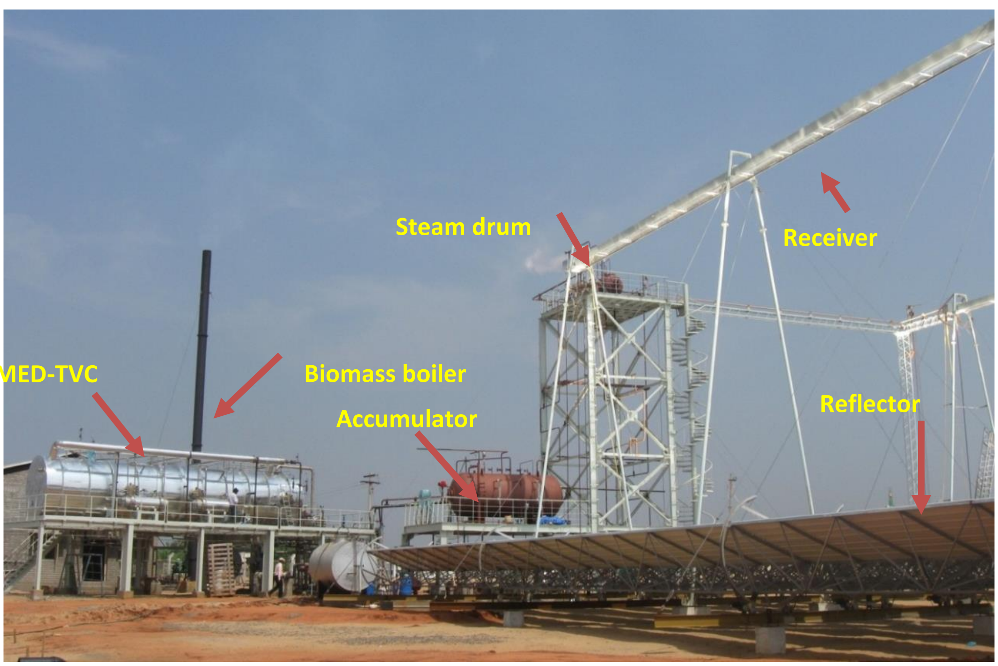


Fig.3 Overall view of the Solar field, MED and biomass boiler in Solar Desalination Plant

5. Lessons from RAMDAS

More than completing a solar-water project, RAMDAS contributed much in-terms of valuable lessons for collaborative efforts in meeting the water requirements in our country. Some of the key benefits of the project are listed below

5.1. Government initiatives

Projects with research elements, social benefits and risk factors need to be initiated by Government. RAMDAS has used special NALSUN4 coating on its absorber tubes, Titanium and aluminium alloys for the evaporator tubes, simultaneous operation of Biomass-Solar Field etc. as its research elements. It is aimed at producing high purity water with TDS less than 2 ppm. Installation and testing of the complete system in a remote sea coast had its own risk factors. DST has initiated many research and development programmes like Solar Mission, WAR for Water etc. to focus on the current research and development needs in the country. RAMDAS is the result of this initiative.

5.2. Private participation

Speedy and successful implementation of projects requires private and industrial participation. RAMDAS could tap the rich industrial experience in terms of technology, material and experienced man power for the design, installation and operation of the project. Confederation of Indian Industry (CII) has recently initiated industrial partnership between industrial and government sectors on water.

5.3. Local needs/resources

Juliflora plants with a calorific value of 3400-3600 kJ/kg are richly available at Ramanathapuram district. RAMDAS project utilized Juliflora for the operation of the bio-mass boiler during the non-sunshine hours. This can generate additional income for the people living around. In addition to that the project employed locally available manpower for its requirements.

The product water is having salinity less than 2 ppm which suits to the industrial requirement in the nearby cities such as Tuticorin. Production of marine algae, production of salt from the reject water etc. are the research projects that can be implemented in future.

5.4. Fundamental research

There are many areas of fundamental research and development such as optimization of the system for least power and best production, effective utilization of solar energy, heat transfer enhancement, thermal and hydraulic analysis etc. for solar steam generation system as well as multi-effect distillation system. IIT Madras assisted in fundamental studies on falling film evaporation by CFD modeling, experimental studies etc. for optimizing the operation of the MED system in RAMDAS project.

The following tables provide a list of key institutions involved in basic research and government agencies involved in various issues related with water. A coordinated effort to meet the water challenges in the country is an essential requirement of the hour [3].

Table 1. Major Research Institutions for water technologies.

Institution		Thrust area
Bhaba Atomic Research Centre	BARC	Seawater/nuclear desalination
Central Salt and Marine Chemical Research Institute	CSMCRI	Membrane desalination
Central Glass and Ceramic Research Institute	CGCRI	Arsenic and Iron removal
National Chemical Laboratory	NCL	Bacteria and virus removal
Bharat Heavy Electrical Limited	BHEL	Membrane and ceramic technology
National Institute of Ocean Technology	NIOT	Low temperature evaporation
Advanced Research Centre for New Materials	ARCI	Nano technology
Indian Institute of Technology Madras	IIT M	Distillation / Nano technology
Indian Institute of Technology Delhi	IIT D	Multi Effect Distillation
Anna University Chennai	AU	Membrane separation

Table 2. Major Government bodies for water technologies.

Institution		Thrust area
Central Water Commission	CWC	Regulation of water
Department of Science and Technology	DST	R&D initiatives
Rajiv Gandhi Drinking Water Mission	RGDWM	Rural drinking water supply
Ministry of Water Resources	MWR	Guidelines on water utilization
Confederation of Indian Industry	CII	Partnership on water
Central Ground Water Board	CGWB	Monitoring ground water resources
Central Soil and Water Conservation Research & Training Institute	CSWCRTI	Water conservation and management
Central Pollution Control Board	CPCB	Pollution monitoring

5.5. Local participation

Local bodies such as panchayats, NGO's need to be get involved in the water related projects as community participation is essential for the implementation. There are many NGO's involved in the water related issues in the country. The village panchayat assisted the RAMDAS project in infrastructure facilities such as road, electricity, etc. and other statutory approvals.

6. Future of Water in India

India has a turbulent water future. It is the right time to incorporate strict water conservation and generation policies to protect the nation from major tragedies associated with water scarcity. Water conservation and efficient water management is important in agriculture sector and industrial sector. Figure 4 shows the water consumption for production of one kg of egg, cotton and milk in India compared to world average.

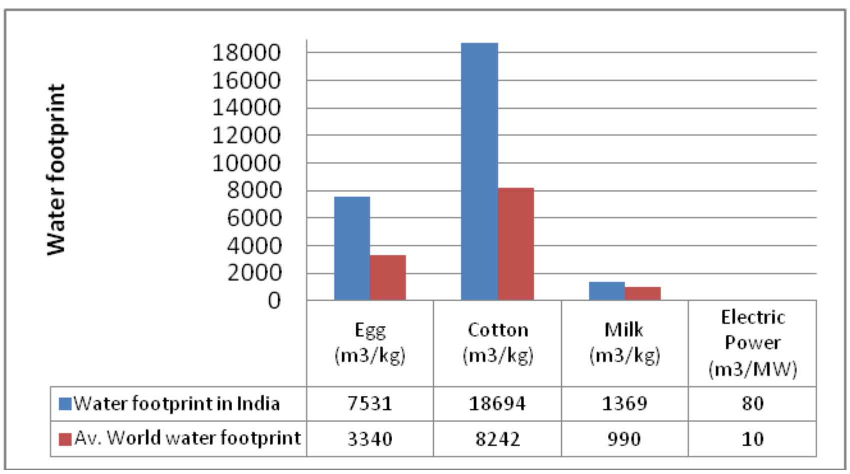


Fig. 4 Water footprint in India

Approximately 85% water is utilized in agriculture sector in India. Similarly 80 m^3/MW water is utilized in power plants in India compared to world average of 10 m^3/MW. Nearly 88% of the industrial water requirement is in power sector. There is great scope for water utilization efficiency improvement [4]. Water utilization standards are to be implemented and monitored. Co-ordination of different agencies at national level is an urgent need. The Govt. of India has initiated a National Water Mission (NWM) with the objectives such as more public-private partnership on water, regulation in water use, and increase in the water use efficiency by 20% etc. These are the steps in the right direction and an awakening and revolution in water sector must take place in our country.

7. Conclusions

There is an increasing water demand due to the falling per capita availability due to rise in population, urbanization, industrialization, indiscriminate use of water, deterioration of water quality, reduction or deterioration of available resources, increasing conflict within regions, inefficient irrigation methods, increase in quality of life, over exploitation and depletion of ground water resources, water-logging and saline water ingression, unwise management of resources etc. Some studies indicate that by 2030 a vast segment of the Indian population could suffer from insufficiency of water for drinking purpose. During the last 40 years, India gradually shifting from a 'water sufficient' nation to 'water stressed' nation. In order to meet the challenges of ever increasing water demand, participation of various agencies and institutions in private and public sector is essential. Desalination of sea water through different technological routes, is energy intensive, posing challenge in power starved villages. RAMDAS is one such step and lessons from the project can provide guidelines for many more initiatives on water. The learning from this project are expected to pave the way for development of suitably up-scaled cogeneration systems capable of producing power as well as water. Solar MED technology can help in addressing potable water problems in coastal areas. It can provide the high quality low ppm water for industrial uses. The operational performance of this plant provides technological leads to plant of higher capacity "Solar Power and Desalination 1 MW electrical power and 1 MLD desalinated water" aimed at generating 1 MWe power and 1 Million Liters per Day (MLD) of desalinated water on a 24×7 basis using the combination of solar and biomass based renewable energy sources . In this manner the villages will be empowered and they will be transformed through economic prosperity. Village health will also improve and happiness quotient will be greatly enhanced in the villages.

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