FINAL REPORT ON

MARKET ASSESSMENT OF SOLAR WATER HEATING SYSTEMS IN INDUSTRIAL SECTORS

Submitted to

MINISTRY OF NEW AND RENEWABLE ENERGY
(Government of India)

Prepared by:

ABPS Infrastructure Advisory Private Ltd.

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ABBREVIATIONS

ABPS	ABPS Infrastructure Advisory Pvt. Ltd.
MNRE	Ministry of New and Renewable Energy
SWHS	Solar Water Heating Systems
BEE	Bureau of Energy Efficiency
EE	Energy Efficiency
ESCO	Energy Service Company
ETC	Evacuated Tube Collector
FPC	Flat Plate Collector
GEF	Global Environment Facility
JNNSM	Jawaharlal Nehru National Solar Mission
MNRE	The Ministry of New and Renewable Energy
NAPCC	National Action Plan on Climate Change
NMEEE	National Mission on Enhanced Energy Efficiency
PAT	Perform, Achieve and Trade
PMU	Project Management Unit
UNDP	United Nation Development Programme
GHG	Green House Gases
CO2	Carbon Dioxide
VCS	Vapour Compression System
VAR	Vapour Absorption Refrigeration System
EC Act 2001	Energy Conservation Act 2001
CIP	Cleaning in Place
CRES	Centre for Renewable Energy Sources

EXECUTIVE SUMMARY

Solar water heating (SWH) is one of the simplest and oldest ways to harness renewable energy and can contribute both to climate protection and sustainable development efforts. Today, the global SWHS market is growing rapidly. In India, SWH is considered as one of the most commercialized renewable energy technologies. Increasingly, hot water is seen as a fundamental aspect of a healthy and hygienic life, and demand for it is growing steadily.

In India, SWH deployment in industrial sector is at early stage of development. Industrial segment requires hot water of low temperature (55-60°C), medium temperature (80°C) and high temperature (more than 100°C)for the wide variety of applications. Depending on the industrial sector, process, location, terrain, climatic profile and economic status, quantum as well as temperature requirement of hot water varies significantly. Also, source of energy for heating water in different industrial sector also varies from region to region. However, it is possible to utilize SWHS to cater medium temperature hot water requirement (up to 80°C) of different industrial sectors and partially replace thermal energy used to produce the same.

Several initiatives taken by MNRE in the last few years have resulted in considerable progress on the SWHS front. However, in spite of the progress, a large portion of the potential is yet to be achieved. In order to achieve scalability and to design innovative marketing, financing and service delivery mechanisms to accelerate penetration of SWHS; assessment of market for potential applications of SWHS in different sectors is required. The sector specific market assessment studies also help in identification of the key barriers and development of sector specific financing and marketing mechanisms.

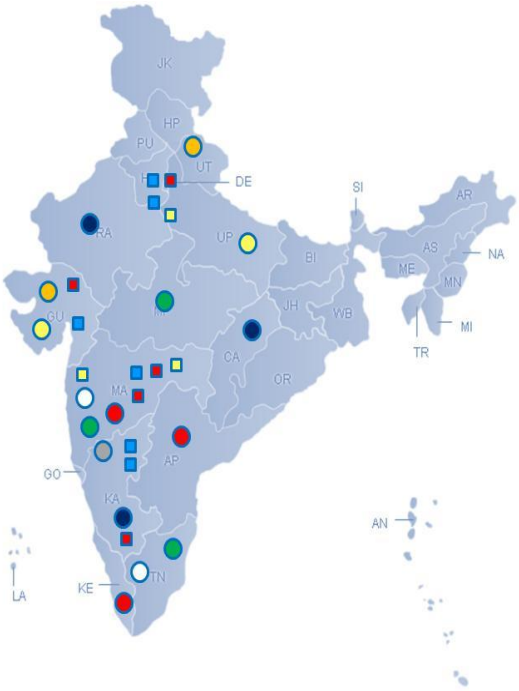
Considering the untapped techno-economic potential, and its realizable benefits of saving of energy and CO_2 emissions, MNRE is looking forward to deployment of SWH systems through ESCO as well as other implementation and financing models.In view of this, Project Management Unit (PMU) of Ministry of New and Renewable Energy engaged ABPS Infrastructure Advisory Private Limited (ABPS Infra) to carry out study to estimate the realizable market potential of SWHS in the different Industrial Sectors and to prepare Action Plan to realize the same. In addition to market assessment, the studywas also expected to identify the experiences and the best practices in those sectors.

As a part of this assignment, mapping of the industry segments and clusters with potential for SWH applications was carried out. Nine Industrial sectors such as Food Processing Industries (Dairy Industry, Beer Industry, Sea Food Processing Industry, and Sugar Industry), Textile Processing Industry, Pharmaceutical Industry, Pulp & Paper Industry, Chemical Industry, Auto Component Industry etc. were identified for the purpose of assessment of the market potential of SWH systems.

This was followed by profiling of the clusters and applications.This kind of profiling was useful to assess needs in different industry segments and to gather issues from various types of stakeholders through field study taken up for two clusters in different states for each industry segment. The figure below highlights the kind of profiling and mapping undertaken while analysing SWH potential in various industrial clusters.

Industry	Clusters Covered
Textile	Tripur/Maharashtra/MP
Paper & Pulp	Muzaffarnagar/Vapi
Food Processing	Sangli/Kochi/Aurangabad
Auto Component	Coimbatore/Pune/Gurgaon
Chemicals, fertilizer, pharmaceuticals	Baroda/ Dehradun
Rural Industries	Raipur
Sugar	North Karnataka/Sangli

Industry	Locality
SWH Manufacturers	Banglore, Delhi, Chandigarh, Pune, Valsad
EA Agencies	Mumbai,Delhi, Banglore, Vadodara
ESCOs	Mumbai, Pune,Delhi



This report is based on the primary research (data and information collected from the ten industries located in two different clusters in different States for each industrial sector), secondary research (macro level data and information collected from various central agencies,

Ministries, CSO, Annual Reports etc.) and stakeholder consultation carried out with Energy Auditing Firms, SWHS Manufacturers, Energy Service Companies and Industrial Associations.

Detailed Approach and Methodology adopted for the execution of the assignment (data collection & estimation of realisable SWHS potential) has been discussed in detail in the 'Chapter One' of this report. The brief overview of the two sectors such as Food Processing (Dairy Industry) and Textile Processing Industrial Sectors and estimation of the maximum achievable SWHS potential in the different scenario is discussed here.

- **Food Processing Industries:**

Food Processing Industry is one of the largest industries in India. As per the Annual Report of Ministry of Food Processing Industry for the year 2009-10, food processing sector contributed over 14% of manufacturing GDP with a share of Rs 2,80,000 Crores.The major segments in the food processing sector comprise of Fruits and Vegetables, Dairy, Edible Oils, Meat and Poultry, Non-alcoholic beverages, Grain-based products, Marine products, Sugar and sugar-based products, Alcoholic beverages, Pulses, Aerated beverages, Malted beverages, Spices, and Salt. Out of these segments, Dairy (16%), Grain-based Products (34%), Baker-based products (20%), and fish and meat products (14%) contribute to a major portion of industry revenue, apart from the manufacturing of beverages. The major States in India where food processing is carried out are Andhra Pradesh (13.4% of India's food processing industry, and a centre for fruits, vegetables and grains), Gujarat (12.7%, and a centre for edible oils and dairy), Maharashtra (14%, and a centre for fruit, vegetables, grains and beverages) and Uttar Pradesh (12%, across almost all product categories). We have carried out detailed assessment of segments such as Food Grain Milling, Dairy Products, Fish Processing and Alcoholic Beverages, which together constitute about 67% of total industry revenue.

- **Dairy Industry:**

India ranks first in the World in terms of Milk Production with annual production of 1131 million tonnes in FY 2009-10. The industry has been recording an annual growth of around 4% during the period 1993-2005, which is almost three times the average growth rate of the dairy industry in the world. Milk processing in India is around 35%, of which the organized dairy industry account for 13% of the milk produced, while the rest of the milk is either consumed at

farm level, or sold as fresh, non-pasteurized milk through unorganized channels. Dairy industry has potential of integration of SWHS for both types of applications such as direct and indirect. As direct application, SWH can be used for the boiler make up water heating as well as for cane and tank washing whereas as indirect application, SWH can be integrated with milk pasteurization process with modern dairy technologies. We have collected data and information from the five dairy industries located in Pune district, Maharashtra in order to estimate the overall SWH potential. We have also calculated the land requirement for SWHS installation to realise the identified potential. Information related to different types of fuels used by the same five industries has also been collected.

We have observed that dairy industries utilise almost all types of fuels such as electricity, coal, bagasse, briquettes, furnace oil etc to meet their energy requirement. We have estimated specific hot water requirement per day per unit of annual production based on the data collected from five industries. We have considered the annual growth rate of the dairy processing industry for the next twelve years and estimated maximum possible SWH penetration in different scenarios (realistic, optimistic and pessimistic) and the same is presented below:

SWH Potential Scenarios in Dairy Industry

		FY13	FY17	FY22
Realistic Scenario	LPD	1625194	4133206	7916446
	M^2	39520	100508	192506
Optimistic Scenario	LPD	1745044	4253056	8036295
	M^2	42434	103422	195420
Pessimistic Scenario	LPD	1505345	4013357	7796597
	M^2	36605	97593	189591

From the above table, it can be seen that cumulative overall realisable SWH market potential will be 192506 square meter of the collector area in the FY 2022 under the realistic scenario (most likely). States like Uttar Pradesh, Punjab, Maharashtra, Madhya Pradesh, Gujarat, Bihar, Rajasthan and Andhra Pradesh offers more than 70% of the realisable SWH potential out of all India potential in the dairy sector.

- **Textile Processing Industry:**

The Indian Textile Industry has an overwhelming presence in the economic life of the country. Apart from providing one of the basic necessities of life, the textile industry also plays a pivotal role through its contribution to the industrial output, employment generation and the export earnings of the country. Currently, it contributes 14% to Industrial production, 4% to the GDP, and 17% to the Country's earnings.

The Indian textile industry can be classified into two categories, organized sector and decentralized sector. Organized sector represents the spinning mills and the composite mills (i.e. spinning, weaving and processing activities carried out in the same premises). Whereas decentralised sector constitutes of handloom sector, power loom sector, hosiery, fabric processing sector, etc. As far as usage of hot water is concerned, there is almost negligible scope for the same in spinning and weaving industries. However, in processing industry, hot water is needed for different chemical processes such as desizing, bleaching and dyeing etc. Hence, we have carried out potential assessment of SWHS in the textile processing sector.

In Textile Processing Industry, direct SWH application is to heat make up water; however the quantity varies depending upon the boiler size and % condensate recovery. In addition to this there is large scope for direct SWH application in various sections such as dyeing, bleaching, etc. In order to quantify maximum realisable SWH potential in Textile Processing Industry, we visited ten textile industries located in the two identified clusters viz. Maharashtra and Tirupur (Coimbatore) for the collection of primary information and data. Out of ten mills, five mills are spinning and weaving mills whereas remaining five are processing mills. In order to strengthen the findings of the study, we collected data of additional five textile processing industries from the study carried out by the Bombay Textile Research Association (BTRA). We have also collected data for different types of fuel used by these industries to meet their thermal and electrical energy requirement.

We have estimated specific hot water requirement per day per unit of fabric processed annually based on the data collected from ten textile processing industries.As per Working group report on Textile and Jute Industry for the 11th five year plan, production of textile processing industries will increase from 9.1 billion m2 during 2005-06 to 38 billion sq. Mtr by the end of eleventh plan. However, we have considered annual growth rate of only 10% for the textile processing industries for the estimation of maximum possible SWH penetration over the next twelve years in different scenarios.

SWH Potential Scenarios in Textile Processing Industry

		FY13	FY17	FY22
Realistic Scenario	LPD	3245842	9303281	20969791
	M^2	78930	226230	509927
Optimistic Scenario	LPD	3994883	11450192	25808974
	M^2	97144	278437	627602
Pessimistic Scenario	LPD	2496802	7156370	16130609
	M^2	60715	174023	392251

Cumulative overall realisable SWH potential for the Textile Processing Industry under realistic scenario will be around 509927 Square Meter in the year FY 2022. States like Tamil Nadu, Maharashtra and Gujarat offers more than 60% of potential out of total realisable SWH potential in the Textile Processing Industrial sector.

We have carried out similar analysis for other industrial segments such as Pharmaceutical Industry, Chemical Industry, Rice Mill Industry, Sea Food Processing Industry, Beer Industry, Sugar Industry and Auto Component including Electroplating Industry. Based on the same, we have estimated overall realizable SWHS potential in above mentioned industrial sectors in three different scenarios and same is provided in the next section.

- **Overall Realizable SWHS Potential in Industrial Sectors**

In total, overall realisable SWH potential for all the Industrial Segments, which include industrial sectors such as Food Processing Industry (Dairy, Sea food, Beer and Sugar), Pulp & Paper Industry, Pharmaceutical Industry, Chemical Industry, Textile Processing Industry, Sea Auto Component Industry and Rice Processing Industry is around 2089758, 1731656 and 133358 square meter by FY 2022 in optimistic, realistic and pessimistic scenarios respectively. Overall realisable SWH potential for all the Industrial Segments in three different scenarios is presented in below table:

Select Scenario		Optimistic			Realistic			Pessimistic		
Industry Segment		FY13	FY17	FY22	FY13	FY17	FY22	FY13	FY17	FY22
Dairy	LPD	**1745044**	4253056	8036295	1625194	4133206	7916446	1505345	4013357	7796597
	m²	42434.6	103422.4	195420.2	39520.18	100508	192505.8	36605.78	97593.61	189591.4
Paper & Pulp	LPD	510115	1413833	3041747	414468.7	1148739	2471419	318822.1	883645.4	1901092
	m²	12405	34380.45	73966.77	10078.72	27934.12	60098	7752.861	21487.78	46229.23
Textile Processing	LPD	3994883	11450192	25808974	3245842	9303281	20969791	2496802	7156370	16130609
	m²	97144	278436.6	627602	78929.79	226229.7	509926.6	60715.23	174022.9	392251.2
Rice Mill	LPD	573538	1430548	2670826	465999.9	1162320	2170046	358461.5	894092.6	1669266
	m²	13947	34786.93	64947	11331.81	28264.38	52769.44	8716.779	21741.83	40591.88
Pharmaceutical	LPD	5175062	12829181	23761569	4204738	10423710	19306275	3234414	8018238	14850981
	m²	125843	311969.8	577814.8	102247.5	253475.4	469474.5	78651.89	194981.1	361134.3
Sea Food Industry	LPD	898447	2227286	4125269	729988.6	1809670	3351781	561529.7	1392054	2578293
	m²	21848	54161.37	100315	17751.28	44006.11	81505.92	13654.83	33850.86	62696.87
Chemical	LPD	894514	2618497	6079194	726793	2127529	4939345	559071.6	1636561	3799496
	m²	21752	63674.53	147829	17673.57	51735.55	120111	13595.05	39796.58	92393.11
Autocomponent incl electroplating	LPD	987727	4083640	9783715	802528.5	3317957	7949268	617329.6	2552275	6114822
	m²	24019	99302.69	237912.6	19515.25	80683.44	193304	15011.73	62064.18	148695.3
Beer Industry	LPD	411192	1173616	2629866	334093.3	953562.6	2136767	256994.8	733509.7	1643667
	m²	9999	28539.04	63950.99	8124.213	23187.97	51960.18	6249.395	17836.9	39969.37
Total	m²	369391	1008674	2089758	305172	836025	1731656	240954	663376	1373553

From the above table,it may be noted Textile Processing Industry and Pharmaceutical Industry constitute a major share of around 29% and 27% respectively out of total realisable SWH potential for all the Industrial Segments in the year 2022 in realistic scenario. However, Dairy Industry, Auto Component Industries, Pulp & Paper Industry, Chemical Industry, Rice Processing Industry, Sea Food Processing Industry and Beer Industry constitute around 11%, 11%, 3.0%, 7.0%, 3.0%, 5.0% and 3.0% out of total realisable SWH potential for all the Industrial segments. States like Tamil Nadu (16.30%), Maharashtra (14.20%), Gujarat (12.32%), Andhra Pradesh (5.84%)Uttar Pradesh (5.00%), Punjab (4.97%) and West Bengal (3.78%) have share of about 65-70% out of total realisable SWH potential for all Industrial Segments.

- **Action Plan for Realization of SWH Potential in Industrial Sectors:**

In order to realise above mentioned SWHS potential and increase the penetration of SWHS in the Industrial sectors, ABPS Infra has suggested following action plan.

- ***Prioritization of Industrial Sectors with positive cost-benefit analysis***

Market Assessment Studies for various Industrial Sectors highlight that there is a promising, suitable and so far almost unexploited market for integration of SWH in the various applications. Hence, it is suggested that Prioritisation of Industrial Sectors should be carried out based on the following important criteria:

- ❖ Industrial Sectors which use high cost of energy (e.g. HSD, LPG, LDO etc.) and have cost of energy per million kCal of useful energy (i.e. after considering conversion efficiency) are the most suitable for SWHS.
- ❖ Industrial Sectors having maximum potential with low and medium temperature hot water requirement.
- ❖ Industrial Sectors in which space constraints are limited.
- ❖ Industry having cleanliness requirements such as pharmaceuticals, dairy and food processing.

MNRE should develop demonstration projects using different technologies for integration of Solar Water Heating Systems for these industries in different clusters in the country.

- ***Development of technology / applications for industries covered under PAT***

MNRE should take into consideration other policies of the Government of India, which encourage integration of renewable energy sources. One such measure is Perform, Achieve and Trade (PAT) mechanism, under which energy efficiency improvement targets (Reduction in Specific Energy Consumption) for nine Industrial Sectors will be specified by the Government. The companies will have to achieve these targets over a period of three years. Most of these sectors are continuous process industries. These industries could use SWH systems to meet their direct and indirect process heat requirement, which would help them in reducing their specific energy consumption. MNRE may also consider developing demonstration projects for the industrial sectors, which are covered under PAT in association with BEE.

- ***Awareness creation workshops for SME clusters***

Generally, awareness about the technology and willingness to deploy new technologies is less among Small and Medium Enterprises (SME). To overcome this barrier, MNRE may consider organisation of workshops and awareness campaigns at major Industrial Clusters. These workshops should be conducted in association with Industrial Associations and following issues should be highlighted during these workshops:

- ❖ Real cost of heat production and use of conventional energy sources and its relevance in the total industry management costs; and
- ❖ Benefits of using appropriate solar thermal technology

- ***Utility Demand Side Management Programs***

There exist potential for SWHS to reduce electrical load by encouraging shift from electrical heating to solar heating. While such potential is not significant in industry, it could be used effectively by utilities with high level of industrial consumption. In this regard, Distribution Utilities will have to prepare and submit specific DSM project along with cost benefit analysis, measurement and verification etc. to the State Electricity Regulatory Commission for its approval. MNRE may provide necessary assistance to distribution companies in identification of target companies and appropriate technologies.

- ***Integration of indirect heating applications***

Based on the market assessment survey, it has been observed that Industrial Sectors offer potential for both direct as well as indirect heating applications. Integration of SWHS for the indirect heating applications is difficult and a complicated task. MNRE may consider capacity building programmes for the various stakeholders such as SWH manufacturers, Industrial Experts to explore untapped potential through indirect applications.

- ***Promotion of ESCO route for deployment of SWH***

During market assessment survey, it was also observed that higher initial capital cost of SWHS is one of the critical barriers, which is hampering the penetration of SWHS in the Industrial Sector. In order to overcome this issue, internationally some of the projects have been implemented through the involvement of Energy Service Companies. In India, Energy Service Companies can also play an important role in increasing the penetration of SWH in Industrial Sectors. In this regard, MNRE can initiate the process of accreditation of the companies as "Energy Service Companies" which has a potential to provide innovative solutions for the integration of SWHS in the Industrial Sectors.

- ***Identification and promotion of high temperature applications***

In Industrial Sectors opportunities exist not only for low and medium temperature applications, but also for the higher temperature applications. Rather, potential for some high temperature applications is huge. Applications such as generation of chilled water through installation of SWHS based VAM for process cooling and comfort cooling, high temperature hot water requirement for process heating, high temperature hot air requirement are some of the examples of the same. Estimation and realisation of potential of high temperature applications will contribute significantly in achieving goal of 20 million square meters for the year 2022 set under JNNSM. Hence, it is suggested that MNRE should initiate a separate study to assess the market potential for SWH systems in Industrial sectors targeting higher temperature applications.

1 INTRODUCTION

This chapter outlines the scope of the Study for 'Market Assessment of Solar Water Heating Systems in the Industrial Sector', and Approach and Methodology adopted for assessing the demand for high potential areas, estimate the realizable market potential and preparation of the Action Plan to realize this potential in the Industrial Sector.

1.1 Background of the Study

The Ministry of New and Renewable Energy(MNRE), Government of India, is implementing a United Nations Development Programme (UNDP) and Global Environment Facility (GEF) assisted Project on "Global Solar Water Heating Market Transformation and Strengthening Initiative: India Country Program".The project is expected to contribute to achieve the 11th plan target through installation of two million sq.m. of Solar Water Heating Systems (SWHS). This will result in Greenhouse Gases (GHG) Emission Reduction of 11 million tons of Carbon Dioxide (CO2) and aims at accelerating development of the market for solar water heating and facilitating the installation of 5 million sq. m. of installed collector area by 2012. The overarching objective of the project is to leverage the Ministry's National Programme and create markets and widespread demand for solar water heating in different sectors especially in untapped potential areas.

1.2 Purpose of the Study

Several initiatives taken by MNRE in the last few years have resulted in considerable progress on the SWHS front. However, in spite of the progress, a large portion of the potential is yet to be achieved. In order to achieve scalability and to design innovative marketing, financing and service delivery mechanisms to accelerate penetration of SWHS;market assessment studies to identify the potential applications of SWHS in different sectors are required. The sector specific market assessment studies will help in identification ofthe key barriers and development of sector specific financing and marketing mechanisms. In addition market assessment studies for SWHS in the industrial sector will also identify the experiences and best practices for Solar Water Heating in the industrial sector. In view of this, Project Management Unit (PMU) of Ministry of New and Renewable Energy engaged ABPS Infrastructure Advisory Private Limited (ABPS Infra) to undertake segment wise market assessment study to estimate the realizable market potential of SWHS in the Industrial Sector and to prepare Action Plan to realize the same.

1.3 Scope of Work

The Scope of Work covers various industrial segments like textile, food processing, auto components including electroplating, chemicals, fertilizers, rural industries etc to assess the market for Solar Water Heating and to prepare the action plan to realize the potential. In order to cover various aspects of market assessment of SWHS in the Industrial Sector, the PMU of MNRE has outlined the terms of reference of the study in three phases as given below:

Phase I – Secondary Information Collection

- Assessment of the International experiences and best practices for Solar Water Heating in the Industrial Sector;
- Collect for domestic industry, segment-wise information on the production; number; types and geographical location of units, typical process-flow diagrams; specific hot-water and steam requirements; application of SWH and other relevant information through literature survey and interaction with industry association; industry experts and solar water heater installers and manufacturers;
- Collect information on future growth prospects of the identified industries and likely future solar water heating demand;

Phase II – Survey for Primary Data Collection

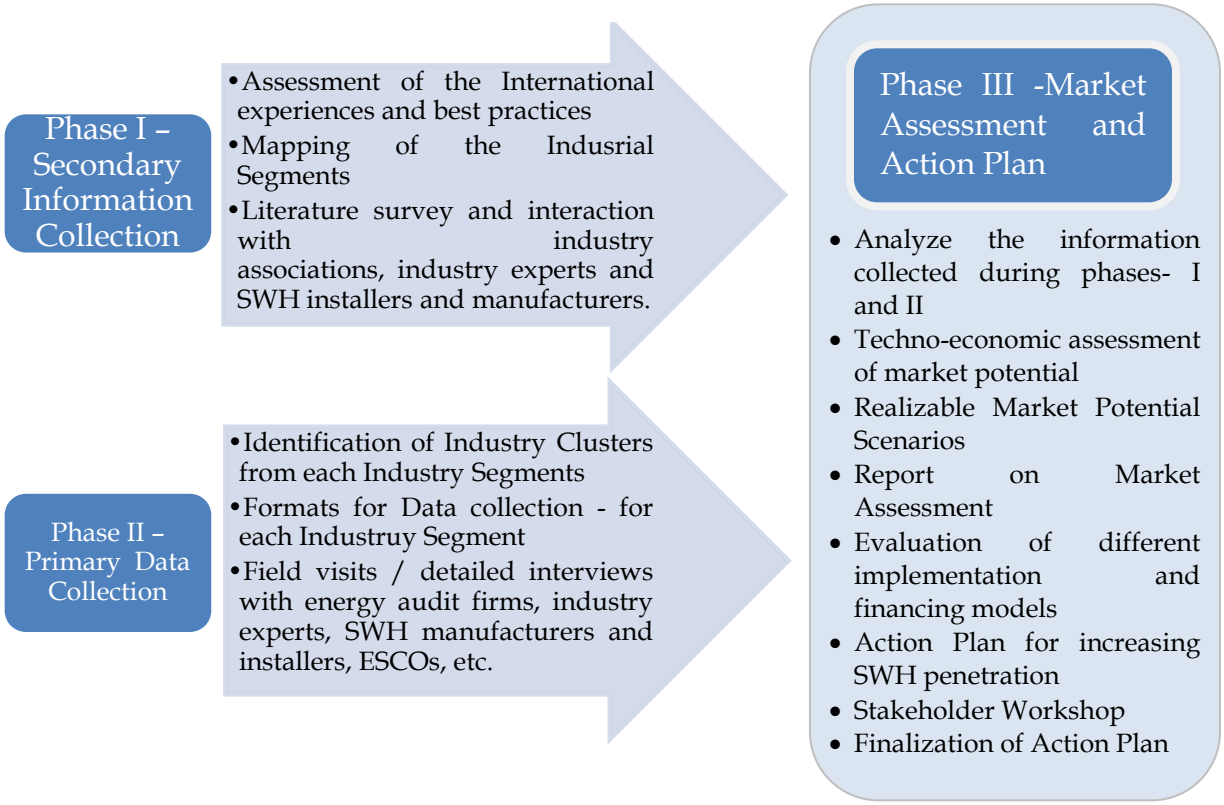
- Visit at least two clusters in different States (covering both SWH user and non-user industries) representing each industrial segment to collect following specific information to gain understanding of water heating requirements and possible solutions:
  - Information on industrial process;
  - How water, steam and other low-temperature heating requirements are met?
  - Specific thermal energy requirements;
  - Fuel used, availability of fuels, economics of thermal energy, etc.
  - Awareness about solar water heaters;
  - Previous experience of applications of SWH'
  - Key barriers in use of SWH etc,
- Supplement the information collected through field visits with detailed interviews with energy audit consulting firms, industry experts, SWH manufacturers and installers, Energy Service Company (ESCO) etc.

Phase III – Assessment of Market Potential and Preparation of Action Plan

- Analysis of the information collected during Phase I & II and preparation of detailed report on assessment of market potential of SWH systems for the Industrial Sector;
- Carry out a techno-economic assessment of market potential based on the data on the segment, survey data, technical and cost information available on SWH products, typical pay-back period and solar resource availability, key barriers in SWH application;
- Estimate and project the realizable market potential under different scenarios for 2013, 2017 and 2022;
- Evaluate different implementation and financing models, such as the ESCO Mode, and prepare an Action Plan for increasing penetration of SWH in industrial sector by 2022;
- Organisation of Stakeholder Workshop and finalisation of the Action Plan

1.4 Approach & Methodology

Diffusion of Solar Water Heating Systems in the Industrial Sector is limited and scattered. We have brought together all the relevant elements that contribute to the market assessment of SWH in the Industrial Sector. We have also mapped our response to the tasks according to the scope of work to appropriately address requirement for secondary and primary data collection through surveys/field visits/detailed interviews and data analysis to assess market potential and preparation of an Action Plan to increase penetration of SWH in the Industrial Sector. ABPS Infra undertook this assignment in a phased manner in order to provide structured approach for carrying out Market Assessment of SWH in Industrial Sector in India. We executed this assignment through three phases as described below:



Phase I – Secondary Information Collection

This phase focused on the identification of various Industrial segments for applicability of SWH based on the collection of the secondary information such as production, number, types and geographical location of units, typical process flow diagrams, specific hot water and steam requirement, application of SWH and other relevant information. The objective of this phase was to conduct a macro study for each of the domestic industrial segment based on the abovementioned collected information. We undertook this phase through three tasks as explained below:

Task I – Identification of Industry Segments, Information Sources & Data Collection

In this task, ABPS Infra in consultation with PMU of MNRE identified and shortlisted various industry segmentsin order to find out various applications of Solar Water Heating systems. ABPS Infra alsoreviewed the information sources for each identified industrial segments for the collection of relevant information. Following tasks were undertaken for this purpose:

- Literature survey of organizations such as Central Statistical Organization (CSO), Centre for Monitoring Indian Economy (CMIE), Confederation of Indian Industry (CII), Industry Associations, Annual Reports, Ministries of each Industrial segmentsto identify national energy consumption and activity statistics for shortlisted industrial sector;

- Interaction with Industry Associations, Ministries, Industry Experts, Solar Water Heater Manufacturers, Energy Auditing firms and ESCO firms to identify the potential applications of SWH systems in the different shortlisted industrial sectors;

- Review of our past experience on similar assignments which involved data compilation of industrial production, future growth prospects of the indentified industries, specific and overall energy consumption, industrial processes etc;

- Compilation of the various information on production, number, types and geographical location of unit, typical process flow diagram, specific hot water and steam requirements gathered through this task;

- Analysis of the collected information to identify the various areas/ applications of SWH in the different Industrial segments;

Task II – Assessment of International/National Experience and Best Practices

International Experience and Best Practices

Through this Task II, ABPS Infra targeted to gather insight into the existing SWH applications in different industry segments in other countries. The assessment of international experiences and best practices helpedinovercoming the barrier of limited knowledge about SWH applications in industry in India.Following tasks were undertaken for this purpose:

- Literature survey to identify various SWH applications implemented in the different industrial segments internationally;
- Identification of various International Stakeholders (e.g. IEA SHC Community) and interaction with them for collection of information pertaining to the SWH implementation in different industrial segments in their countries;
- Review of different SWH projects implemented in the different industrial sectors;
- Review of existing implementation and financing model adoptedindifferent countries;
- Cost benefit analysis of the different projects and identification of the barriers;

- Assessment of effectiveness of the projects implemented in different industrial sectors;
- Compilation of important information gathered through this task;
- Compilation of the lessons learnt and best practices from schemes implemented in different countries;

Based on the collected information, we had prepared six case studies on projects implemented in different Industrial sectors internationally and presented in Annexure I of this report.

National Experience and Preparation of Case Studies

In this task, ABPS Infra contacted various stakeholders such as SWH Manufacturers, ESCO firms, Energy Auditing Firms and Industry Experts in order to identify SWH projects implemented in Industrial Sectors in India. ABPS Infra also visited a couple of Industries where these projects were implemented in order to understand the performance of the system and various barriers faced by them during implementation. Based on the collected information, seven case studies implemented in the various industrial sectors such as Chemical, Pharmaceuticals, Food Processing and Textile sectorswere prepared and included in the Annexure II of the report.

Task III – Mapping of the Industrial Segments

In this task, profiling/mapping of industry segments associated with SWH such as Textile, Food Processing, Dairy, Auto Components including Electroplating, Chemicals, Sugar etc. was carried out. Profiling was done on the basis of various criteria such as regional spread, industrial clusters, SWH technologies and their applications. This kind of profiling gave us insightsintothe needs and application of SWH systems in different industry segments. The profiling also helped us to gather issues to be addressed during the field study for two clusters in each industry segments.

Phase II – Primary Information Collection

The purpose of this phase was to collect the primary information through field visits to the industrial units and understand issues from different types of stakeholders such as SWH Manufacturers, Energy Auditing Firms, ESCO firms, Industry Associations etc through

interview in order to assess the need of SWHS in different industrial segments and to gain understanding of water heating requirement and possible solutions. Under this phase we undertook the following tasks:

- Identification of two industry clusters in different States for each industry segment based on the profiling of the industry segment carried out in Phase I;

- Identification and short listing of five industries from each industry cluster for each industry segment;

- Identification and short listing of firms from SWH Manufacturers and Installers, Energy Auditing firms and ESCO for interview purpose;

- Preparation of three different data collection formats such as Primary data collection format, Stakeholder Consultation format and International SWH Case Study format;

- Primary data collection format sought information related to process flow, different forms of energy utilized and associated costs, potential areas / equipments for hot water / hot air applications, process and comfort cooling requirements and associated parameters such as temperature range, capacity, present source of energy and its cost. Primary data collection format is provided in Annexure III at the end of this report.

- Stakeholder Consultation Formatsoughtviews of SWH Manufacturers, Energy Audit Firms and ESCO firms about theirviews/ recommendations to identify the barriers for implementation of SWH, to identify the most preferred mode of finance for implementation of SWH projects, and also their views about SWH technology development, its costs, domestic demand, industry drivers etc. Stakeholder Consultation format is provided in Annexure IV at the end of this report.

- SWH Case Study format sought information related to various aspects of the projects implemented such as implementer, objective, project target, technology used, and drivers for implementation, barriers addressed, overall effectiveness assessment, cost benefit analysis and applicability of the same projects in other industrial segments. SWH Case Study format is provided in Annexure V at the end of this report.

- Field visit and survey of five industries from each identified industry cluster and each industry segment was carried out to assess the hot water requirements and possible solutions through SWH systems;

- Collection of information such as information on industrial processes, hot water steam and other low temperature heating requirements, specific thermal energy requirements, fuel used, availability of fuels, economics of thermal energy, awareness about solar water heaters, previous experience of SWH, key barriers for use of SWH etc.

The outcome of these tasks helped us in identifying and assessing the existing needs of SWH in different industrial segments in different regions. The outcome of these tasks also helped us in identifying the reasons for limited success in deployment of SWHS. The outcome of these tasks also helped us in identifying the financial and business needs of the different industry clusters, industry segments and regions and highlighted the categories, which require special attention for penetration of SWH.

Phase III – Assessment of Market Potential and Preparation of Action Plan

Secondary and Primary information collected during Phase I and Phase II was analyzed to prepare a detailed report on assessment of market potential of SWH systems for the industrial sector in the country. We undertook this phase through two tasks as explained below:

Task I: Market Assessment of Solar Water Heating Systems

In this task, ABPS Infra carried out analysis of data collected to identify SWH demand drivers in different industrial segments. Based on the analysis, ABPS Infra developed three scenarios for projecting SWH demand– realistic or most likely, optimistic and pessimistic by considering direct and indirect SWH application in the industry processes, type and cost of fuel used, land requirement and availability, economics of SWH options and temperature range of hot water required. Following tasks were undertaken for estimation of realizable SWH potential:

- Analysis of data to estimate overall SWH potential specific to each industrial segments;

- Annual production in the base year (FY 2010) was estimated based on the annual production in the previous year and growth rate in the same year.

- Increase in the annual production for each industrial sector, year on year for the next twelve years was estimated by multiplying the annual production with growth rate in the particular year.

- Primary data on market assessment collected through field visit was analyzed to calculate the specific hot water requirement per day per unit of production/number of units installed for both direct and indirect application;

- The specific hot water requirement per day was multiplied by annul production in base year (FY 2010) to calculate the overall hot water requirement (Overall SWH Potential) specific to each industry segment for direct as well as indirect SWH applications.

- Collector area and hence land requirement for SWH implementation was assessed after considering the average global solar radiation in India and seasonal variation;

- Percentage implementable SWH capacity in the land available with industries assessed in each industry segment was applied to the overall SWH potential to get the maximum achievable SWH potential in each industry segment after considering space constrain;

- Percentage of SWH penetration over the next twelve years was estimated for each industry segment after analyzing the following parameters:

    - Possible Implementable SWH potential after considering Land Availability

    - Comparing % of energy used in different industry segments and cost of energy per million kCal of useful energy (Rs/ MkCal) (i.e. after considering the conversion efficiency) across different industry segments;

- Assumptions were made to identify overall SWH penetration over the span of twelve years for different industry segments under different scenarios- Realistic or most likely, Optimistic and Pessimistic;

- ABPS Infra also participated in two workshops "Interaction Meet on Renewable Energy Options for the Industrial Sectors" organized by MNRE, UNDP & GEF in association with the two State Nodal Agency at Rudrapur (Uttrakhand) and Ludhiana (Punjab) and presented finding / potential assessment carried out for the couple of industrial sectors to solicit the views of the stakeholders present at the meets.

Task II: Preparation of National Action Plan

In this task, we have prepared the draft action plan for realization of SWH potential in industrial sectors by considering realizable market potential under different scenario for 2013, 2017 & 2022. This action plan mainly emphasizes on the prioritization of various industrial sectors to be targeted for the SWH implementation, capacity building and awareness programmes for the various stakeholders, development of pilot programmes for the different climatic zones, development of best practices for the domestic industrial applications etc. in order to increase the penetration of SWH in the industrial sectors.

Preparation and Submission of the Revised Draft Report:

ABPS Infra prepared draft report on Market Assessment of SWH in the Industrial Sector and submitted to the PMU of the MNRE. ABPS Infra also gave the presentation on the findings of the draft report to the PMU. Apart from PMU, senior officers from MNRE, UNDP, GEF and IREDA were present during the presentation. MNRE raised the clarifications/ comments on the draft report and asked ABPS Infra to revise the estimation of SWH potential by including analysis of couple of more sub-sectors in food processing industries and Auto component industries. MNRE also asked ABPS Infra to revise the estimate of textile processing industries by including analysis of five more industries. ABPS Infra collected data from five more textile processing industries and revised the estimates based on the same. ABPS Infra also visited four Auto Component Industries located in Gurgaon and Manesar Clusters and estimated the SWH potential in Auto Component Industries. ABPS Infra also visited five beer manufacturing facilities located at Aurangabad in order to collect the primary information and carried out detailed analysis to estimate the maximum possible realizable SWH potential and same has been included in this revised draft report.

Preparation and Submission of the Final Report

As mentioned above, ABPS Infra prepared revised draft report on Market Assessment of SWH in the Industrial Sector and submitted to the PMU of the MNRE. ABPS Infra also gave the

presentation on revised draft report to the PMU on May 9, 2011. MNRE gave comments on the revised draft report and asked ABPS Infra to submit the final report after incorporating the same. ABPS Infra collected three more case studies of the projects implemented in industrial sectors such as Textile, Pharmaceutical and Food Processing and included in the report as Annexure. ABPS Infra has also addressed other comments given by the MNRE and modified thereport accordingly.

1.5 Outline of the Research Report:

In the subsequent Chapters of this Final Report, ABPS Infra has covered the following areas of study:

Chapter 1 presented the background, purpose, scope and approach adopted in the execution of the Market Assessment of Solar Water Heating Systems in Industrial Sector assignment.

Chapter 2 presents the overview of Solar Water Heating Sector in India to provide a complete view of the potential and development of the SWH sector in India. This chapter also provides the outline of Jawaharlal Nehru National Solar Mission and National Mission on Enhanced Energy Efficiency.

Chapter 3 highlights the five major areas for integration of Solar Water Heating Systems in the different industrial sectors. This chapter also provides the information related to the abovementioned five major areas.

Chapter 4 presents the approach and methodology adopted for collection of data and estimation of the overall SWH potential in the different industrial sectors. This chapter also highlights various assumptions made to estimate the realisable market potential for SWH integration in different industrial sectors in different scenarios.

Chapter 5 presents the overview of the Food Processing Industries, overview of sub-sectors within food processing industry (Dairy, Sea Food Processing Industries, Beer Industry and Sugar Industry), processes and potential areas for SWH integration. This chapter also presents

the assessment of realisable market potential for integration of SWH system in the Food Processing Industries and its different sub-sectors.

Chapter 6presents the overview of the Rice Mill Processing Industry and assessment of realisable market potential for integration of SWH system.

Chapter 7 presents the overview of the Textile Processing Industry and assessment of realisable market potential for integration of SWH systems;

Chapter 8 presents the overview of the Pharmaceutical Industry and assessment of realisable market potential for integration of SWH systems;

Chapter 9 presents the overview of the Pulp and Paper Industry and assessment of realisable market potential for integration of SWH systems;

Chapter 10 presents the overview of the Chemical Industry and assessment of realisable market potential for integration of SWH systems;

Chapter 11 presents the overview of the Auto Component Industries and assessment of realisable market potential for integration of SWH systems;

Chapter 12 presents the State wise overall SWH Potential in India

Chapter 13discusses the National Action Plan, which is prepared to harness SWHS potential and increase penetration of SWH systems in the industrial sectors.

2 OVERVIEW OF SOLAR WATER HEATER SECTOR IN INDIA

This Chapter begins with review of development of solar water heating sector in India. It further presents different types of solar water heating systems and their working. The Chapter also discusses the potential for SWHS in India, National Solar Mission and proposed Perform, Achieved and Trade scheme (PAT) under National Mission on Enhanced Energy Efficiency. This Chapter also highlights the scenario for development of SWH sector in the country.

2.1 Solar Energy

India's theoretical solar power reception on its land area is about 5000 trillion kWh per year. India has nearly 300-330 clear sunny days and average daily solar energy incidence varies from 5 to 7 kWh/sq. m. The sun provides a virtually unlimited supply of energy. The energy from the sun is virtually free once the initial cost of the system has been recovered.The use of solar energy can, not only bridge the gap between the demand and supply of electricity but it also displaces conventional energy, which usually results in a proportional decrease in GHG emissions. Solar energy usage in India is merely 0.5% compared to other energy resources.

2.2 Solar Water Heaters – Types and Usage

Solar water heating has applications in several consuming categories such as domestic, hotels, institutions, industrial etc. Quantity and temperature requirement vary with the type of application for different consumer categories. Designs and structures of the solar water heaters also vary depending on the quantity and temperature requirement of the application. While systems used in domestic application are fairly standard, systems used for institutional and industrial applications are customised for the desired application.

Solar water heating systems could be divided into two types, depending upon the method of water circulation. In the thermo-syphon systems, hot water is supplied using gravity of the principles. These systems are usually simple and relatively inexpensive. As name suggests, the forced circulation systems employ electrical pumps to circulate the water through collectors and storage tanks.

While abovementioned differentiation of SWH systems is technically correct, SWH Systems for industrial and commercial applications are better known by the type of solar collector used. Based on the type of collectors, SWHS are divided into following three types:

- Flat Plate Collectors (FPC)

- Evacuated Tube Collectors (ETC)
- Solar Concentrator

In the following paragraphs, we have described these in more detail.

2.2.1 Flat Plate Collector

A black absorbing surface (absorber) inside the flat plate collectors absorbs solar radiation and transfers the energy to water flowing through it. The solar radiation is absorbed by flat plate collectors, which consist of an insulated outer metallic box covered on the top with glass sheet. Inside there are blackened metallic absorber (selectively coated) sheets with built in channels or riser tubes to carry water. The absorber absorbs the solar radiation and transfers the heat to the flowing water.

2.2.2 Evacuated Tube Collector

The collector is made of double layer borosilicate glass tubes evacuated for providing insulation. The outer wall of the inner tube is coated with selective absorbing material. This helps absorption of solar radiation and transfers the heat to the water, which flows through the inner tube. ETC is highly efficient with excellent absorption (>93%) and minimum emittance (<6%) as the tubes are round and sun rays are striking the tubes at right angles thus minimizing reflection. The entire system is controlled and monitored by an automatic control panel. There is no scaling in the glass tubes thus, suitable for areas with hard water.

2.2.3 Solar Concentrator

Solar Concentrator is a device, which concentrates the solar energy incident over a large surface onto a smaller surface. The concentration is achieved by the use of suitable reflecting or refracting elements, which results in an increased flux density on the absorber surface as compared to that existing on the concentrator aperture. In order to get a maximum concentration, an arrangement for tracking the sun's virtual motion and accurate focussing device is required. Thus, a solar concentrator consists of a focussing device, a receiver system and a tracking arrangement. Temperature as high as 3000 deg C can be achieved using solar concentrators, and hence they have potential applications in both thermal and photovoltaic utilisation of solar energy at high delivery temperatures.

2.3 Benefits of Solar Water Heating Systems

Solar water heating systems or SWHS can easily heat water to temperature of 60-80° C.A 100 litres capacity SWHS can replace an electric geyser of 2 KW capacities, for residential use and may save up to 1500 units of electricity annually depending upon the location of the SWHS. The result of Market Assessment Survey carried out by 'Greentech Solutions' clearly brings out diversity in requirement of hot water across different parts of the country.

While in some parts of the country where hot water requirement is for 9 months or more, the SWHS may save about 1400-1500 units of electricity, the systems in other parts such as Rajasthan/ Delhi my save only 600-800 units per annum. The use of 1000 SWHS of 100 litres capacity each can contribute to a peak load shaving of approximately 1 MW while one SWHS of 100 litres capacity can prevent emission of up to 1.5 tons of CO_2 per year. SWHS systems have a vast potential in homes, hotels, hospitals, hostels, dairies, industries, institutions, govt. buildings etc. Large scale installations of SWHS could save enormous amount of electricity besides having load shavings during peak hours & abating CO2 emission.

2.4 Potential and Achievements of Solar Water Heating Systems

The gross potential for SWHS in India has been estimated to be 140 million sq. m. of collector area. Of this, 40 million sq.m.has been estimated as the realizable techno-economic potential at this stage. A total of 3.53 million sq. m. of collector area has so far been installed in the country for solar water heating, of which about 1.55 million sq. m. has been installed since 2005-06. The achievement so far has been modest as compared to the overall potential. A target of 5 million sq. m. has been set for the 11th Plan (2007-12) and a goal of 20 million sq. m for 2020. Recently the Jawaharlal Nehru National Solar Mission (JNNSM) has been announced, and as per the mission, the deployment of SWHS has been divided into three phases. The target of 7 million sq. m. has been set for phase I i.e. FY 2010-13, 15 million sq. m. for phase II i.e. FY 2013-17 and 20 million sq. m. for phase III covering period FY 2017-22. The year wise achievement of SWHS has been shown below in Table 2.1:

Table 2.1: Year wise achievement of SWHS

Year	Achievements (In sq m of collector area)
Up to 2002-03	**6,50,000**
2002-03	1,00,000
2003-04	1,50,000
2004-05	2,00,000
2005-06	4,00,000
2006-07	4,00,000
2007-08	4,50,000
2008-09	3,00,000
2009-10	8,80,000
2010-11 (as on 31/01/2011)	3,70,000
Total	39,00,000

Source: www.mnre.gov.in

2.5 Jawaharlal Nehru National Solar Mission

The Jawaharlal Nehru National Solar Mission (JNNSM) is a major initiative of the Government of India and State Governments to promote ecologically sustainable growth while addressing India's energy security challenge. It will also constitute a major contribution by India to the global effort to meet the challenges of climate change. This Mission is one of the eight key National Missions, which comprise India's National Action Plan on Climate Change or NAPCC.

The objective of the National Solar Mission is to establish India as a global leader in solar energy, by creating the policy conditions for its diffusion across the country as quickly as possible. The Mission includes major programme titled '***The Below 80^{0}C Challenge – Solar Collectors***' for Solar Thermal Technology. Key provisions of the National Solar Mission in this regard are reproduced below:

2.5.1 The below 80°C challenge – solar collectors

The Mission in its first two phases will promote solar heating systems, which are already using proven technology and are commercially viable. The Mission is setting an ambitious target for ensuring that

applications, domestic and industrial, below 80 °C are solarised. The key strategy of the Mission will be to make necessary policy changes to meet this objective:

- *Firstly, make solar heaters mandatory, through building byelaws and incorporation in the National Building Code,*
- *Secondly, ensure the introduction of effective mechanisms for certification and rating of manufacturers of solar thermal applications,*
- *Thirdly, facilitate measurement and promotion of these individual devices through local agencies and power utilities, and*
- *Fourthly, support the upgrading of technologies and manufacturing capacities through soft loans, to achieve higher efficiencies and further cost reduction."*

2.5.2 Policy and Regulatory Framework

The objective of the National Solar Mission is to create a policy and regulatory environment, which provides a predictable incentive structure that enables rapid and large-scale capital investment in solar energy applications and encourages technical innovation and lowering of costs. The Mission would seek to establish a sector-specific legal and regulatory framework for the development of solar power, in the shorter time frame.

The National Tariff Policy 2006 mandates the State Electricity Regulatory Commissions (SERC) to fix a minimum percentage of energy purchase from renewable sources of energy taking into account availability of such resources in the region and its impact on retail tariff. Mission envisages that National Tariff Policy, 2006 would be modified to mandate that SERCs fix a percentage for purchase of solar power. The solar power purchase obligation for States may start with 0.25% in the phase I and to go up to 3% by 2022. This could be complemented with a solar specific Renewable Energy Certificate (REC) mechanism to allow Utilities and solar power generation companies to buy and sell certificates to meet their solar power purchase obligations.

2.5.3 Targets under the Mission

National Solar Mission has framed the target for solar generated power for grid connected as well as the distributed and decentralized off-grid commercial energy services which has been depicted in the table 2.2 given below:

Table 2.2: Target set for grid connected and off grid solar power

S.No.	Application segment	Target for Phase I (2010-13)	Target for Phase 2 (2013-17)	Target for Phase 3 (2017-22)
1	**Solar collectors**	**7 million sq meters**	**15 million sq meters**	**20 million sq meters**
2	Off grid solar applications	200 MW	1000 MW	2000 MW
3	Utility grid power & roof top	1,000-2000 MW	4000-10,000 MW	2000 MW

2.6 Achievement Status of Off-grid Renewable Power

The table below provides the achievements and cumulative achievements of off-grid / distributed renewable power including captive or CHP plants as on, and also provides the decentralized energy systems up to January 31, 2011. June 30, 2010.

Table 2.3: Achievements Status of solar associated applications

	Cumulative Achievements (upto 31/01/2011)
Solar PV Power Plants (Grid Connected)	31.4 MWp
SPV Home Lighting System	6,69,805 nos.
Solar Lantern	8,17,549 nos.
SPV Street Lighting System	1,22,697 nos.
SPV Pumps	7,495 nos
Solar Water Heating - Collector Area	3.90Mln. sq.m.

Source: www.mnre.gov.in

2.7 National Mission on Enhanced Energy Efficiency

Government of India has been promoting greater energy efficiency through various policy measures. Increased attention at policy level is also visible with the release of the National Action Plan on Climate Change (NAPCC) with "National Mission on Enhanced Energy

Efficiency (NMEEE)" as one of the missions under NAPCC. NMEEE highlights four new initiatives to enhanced energy efficiency:

- A market based mechanism to enhance cost effective EE improvements in energy-intensive industries and facilities, through Tradable Energy Savings Certificates. (Perform Achieve and Trade(PAT))
- Accelerating the shift to energy efficient appliances through innovative measures to make the products more affordable. (Market Transformation for Energy Efficiency)
- Creation of mechanisms that would help finance Demand Side Management(DSM) programmes in all sectors by capturing future energy savings. (Energy Efficiency Financing Platform (EEFP))
- Developing fiscal instruments to promote energy efficiency namely Framework for Energy Efficient Economic Development (FEEED)

All abovementioned four programmes are important in the context of Solar Water Heaters as a Demand Side Management and Energy Efficiency measures. Out of four, the "Perform, Achieve and Trade" (PAT) mechanism is probably the most innovative and challenging initiative. Under the Energy Conservation Act, 2001 (EC Act 2001), industrial units in nine sectors, with energy consumption exceeding specified thresholds, have been notified as Designated Consumers (DCs). Installations from Cement, Fertiliser, Iron & Steel, Pulp & Paper and Thermal Power Plant with energy consumption of 30000 metric tonnes of oil equivalent per year or above are identified as DCs, whereas as for Chlor-Alkali, Aluminium and Textile sectors, this norm is 12000, 7500 and 3000 metric tonnes of oil equivalent per year or above respectively. The PAT mechanism would provide energy efficiency improvement target (Reduction in Specific Energy Consumption) for each notified Designated Consumers and these targets would need to be achieved over a three-year period. These DCscould use SWH systems to meet their direct and indirect process heat requirement, which would help them in reducing their specific energy consumption target. Thus, National Mission on Enhanced Energy Efficiency can play an important role in order to increase the penetration of SWH systems in the Industrial sectors, which is very less and scattered in India.

3 SOLAR WATER HEATRING AREAS IN INDUSTRIAL SECTORS

Solar water heating (SWH) is one of the simplest and oldest ways to harness renewable energy and can contribute both to climate protection and sustainable development efforts. Today, the global SWHS market is growing rapidly. China's market, by far the world's largest, has increased dramatically over the past 20 years, with 40 million square meters of total installed capacity in 2002. Over one-third of homes in Barbados are equipped with SWH systems, and in India, SWH is considered among the country's most commercialized renewable energy technologies. Increasingly, hot water is seen as a fundamental aspect of a healthy and hygienic life, and demand for it is growing steadily.

In India, Industrial SWH penetration is at premature stage of development. Industrial segment requires hot water of low (55-60°C), medium (80°C) and high temperature (more than 100°C)rangefor the wide variety of applications. Depending on the industrial sector, process, its location, terrain, climatic profile and economic status, quantum as well as temperature requirement of hot water varies significantly. Also, source of energy for heating water in different industrial sector also varies significantly from region to region. However, it is possible to integrate SWHS in order to cater the medium temperature requirement (up to 80°C) of the different industrial sectors and partially replace thermal energy requirement of that particular area effectively. Considering the untapped techno-economic potential, and its realizable benefits of saving of energy and CO_2 emissions, MNRE is looking forward to penetrate SWH systems sustainably in this demand segments through ESCO as well as other implementation and financing models.In this section of report, we have identified the major areas where it is possible to integrate SWHS and partially replace the thermal energy requirement of that particular area. We have also discussed these major areas in brief in the subsequent section.

3.1 Major Areas for Integration of SWHS in Industrial Sectors

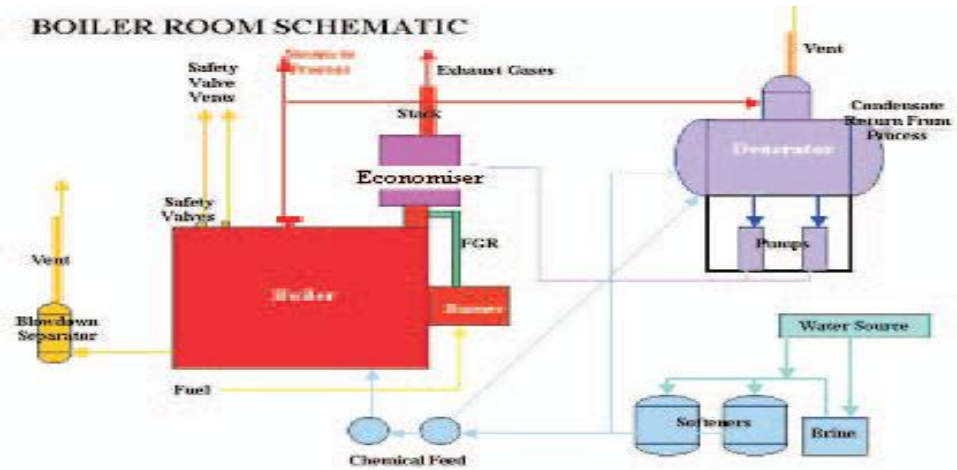
We have collected information in order to identify various areas of hot water requirement for each industrial sector based on the secondary research and interaction with Industry Experts, Industrial Association, SWH Manufacturers, Energy Auditing and Energy Service Companies. Based on the same, we have divided potential areas in Industries for SWHS integration into the following five major categories:

- Solar Potential for Boiler Feed Water Heating;
- Solar Potential for Process Heating;
- Solar Potential for Process Cooling (through installation of VAM)
- Solar Potential for Comfort Cooling (through installation of VAM)
- Solar Potential for Hot Air Generation

Brief description of each of the abovementioned category is provided below:

3.1.1 Solar Potential for Boiler Feed Water Heating Systems

A Boiler is an enclosed vessel that provides a means for combustion heat to be transferred into water until it becomes heated water or steam. The hot water or steam under pressure is then utilised for transferring the heat to a process. Most of the industrial sectors utilise steam/hot water in order to fulfil their various heating requirement. The boiler system mainly comprises of: feed water system, steam system and fuel system. The feed water system provides water to the boiler and regulates it automatically to meet the steam demand. The steam system collects and controls the steam produced in the boiler. Steam is directed through a piping system to the point of use. The fuel system includes all equipment used to provide fuel to generate the necessary heat. Different types of fuels such as solid, liquid and gaseous fuels are being used in the different industrial sectors for the generation of the steam. A typical schematic diagram of Boiler systems is shown in Figure 3.1



The water supplied to the boiler that is converted in to the steam is called feed water. Typically, in most of the industries, two main sources of feed water are:

- Condensate or condensed steam returned back from the process; and
- Make up water (treated water) which come from outside the boiler room;

In order to increase the efficiency and reduce the fuel requirement, various industrial sectors have installed economiser to preheat the boiler feed water using waste heat in the flue gas. However, Temperature of the boiler feed water depends on the percentage recovery of the condensate and performance of the installed economiser. Also, Quantity of make up water requirement varies from industry to industry based on the percentage of the condensate recovered. In such case, it is possible to heat the boiler feed water either fully or partially (only make up water requirement) by installing solar water heating systems to the temperature up to 70 to 80°C before being supplied to the boiler. This will help to reduce the quantity of fuel required in the boiler. It is also easy to integrate with the existing process and simple to implement. However, the economics of this option varies from industry to industry and is entirely depends on the type of fuel utilised, percentage of the condensate recovered and performance of the economiser.

3.1.2 Solar Potential for Process Heating

Various industries require hot water of the different temperature ranges for the wide variety of the applications. Quantity, quality and temperature requirement of hot water varies from industry to industry, its processes, regions and climatic zones. Some of the industrial sectors, which require hot water for the different applications are textile processing industry, pharmaceuticals industry, pulp and paper industry and rice industry etc. These industrial sectors have installed hot water generation systems using conventional fuel (fuel or electricity) in order to cater their hot water requirement. Also, some of the industrial processes, hot water is being used for direct heating application whereas for other industrial processes, it is being used indirectly. It is relatively easy to install Solar Water Heating systems and integrate with existing process for the direct application; however it is difficult and complex for the applications, which require hot water indirectly. Economics of this option also varies for different industrial sectors and mainly depends on the type of fuel utilized for the generation of hot water.

3.1.3 Solar Potential for Process Cooling

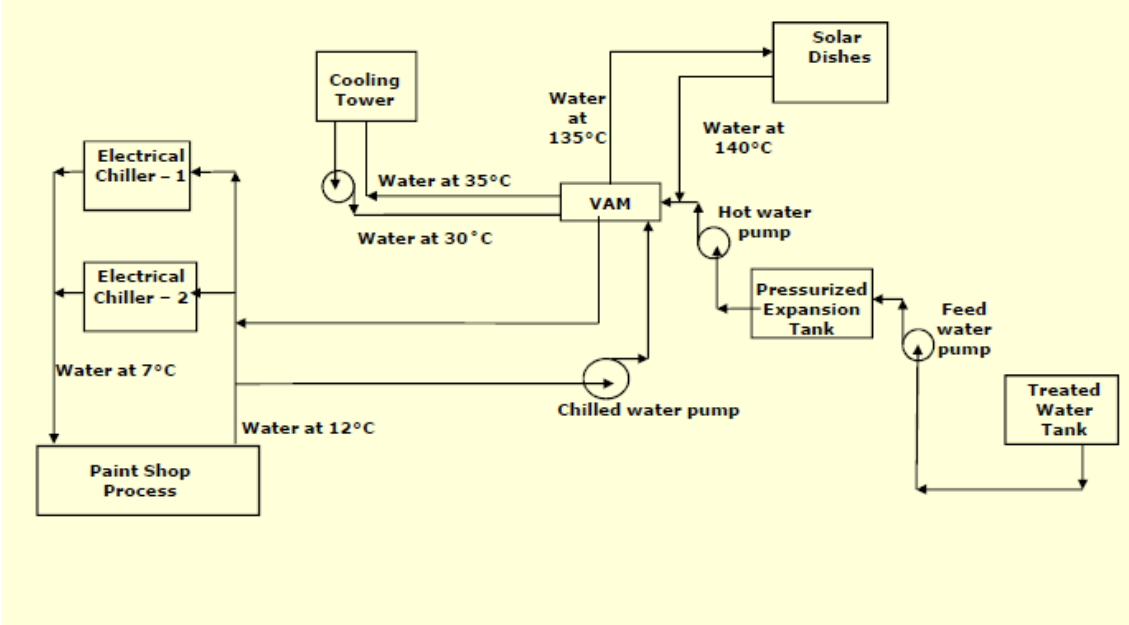
Various industries such as Pharmaceuticals, Chemical, Food Processing, etc requires chilled water at different temperatures ranges (such as 8 to 10°C, sub zero temperature etc.) in order to cater their process chilling requirements. In this regard, same industrial unit may have installed different systems tocater their chilled water requirement at different temperature. Two principle types of refrigeration plants found in the industrial use are Vapour Compression Refrigeration System (VCR) and Vapour Absorption Refrigeration System (VAR). VCR uses mechanical energy as the driving force for refrigeration, while VAR uses thermal energy as the driving force for the generation of refrigeration.

Heat flows naturally from a hot to a colder body. In refrigeration system the opposite must occur i.e. heat flows from a cold to a hotter body. This is achieved by using a substance called a refrigerant, which absorbs heat and hence boils or evaporates at a low pressure to form a gas. This gas is then compressed to a higher pressure, such that it transfers the heat it has gained to ambient air or water and turns back (condenses) in to a liquid. In this way, heat is absorbed, or removed from a low temperature source and transferred to a higher temperature source. Vapour Compression Machine mainly comprises of compressor, evaporator, condenser, chilled water pumps and cooling water pumps etc. Around 70% of the total energy consumption in entire refrigeration system takes place in the compressor alone.

Whereas, the Vapour Absorption Chiller is a machine, which produces chilled water by using heat such as steam, hot water, gas, oil etc. Chilled water is produced by the principle that liquid (refrigerant), which evaporates at low temperature, absorbs heat from surrounding when it evaporates. Pure water is used as refrigerant and lithium bromide solution is used as absorbent. Heat for the vapour absorption refrigeration system can be provided by waste heat extracted from the processes, diesel generator sets etc. Absorption systems require electricity to run pumps only (Chilled water pumps and cooling water pumps). Depending on the temperature required and the power cost, it may even economical to generate heat/steam to operate the absorption system.

As mentioned above, many industrial segments require chilled water to cater process chilling requirements and have installed vapour compression machine. In order to save electricity, industrial units utilizing Cogeneration / Diesel Generating sets for the generation of electricity, have also installed Vapour Absorption Machine in order to fulfill their chilled water requirement. However, in order to generate and get the chilled water round the clock, it is important to maintain heat input to the Vapour Absorption Machine. It may be difficult

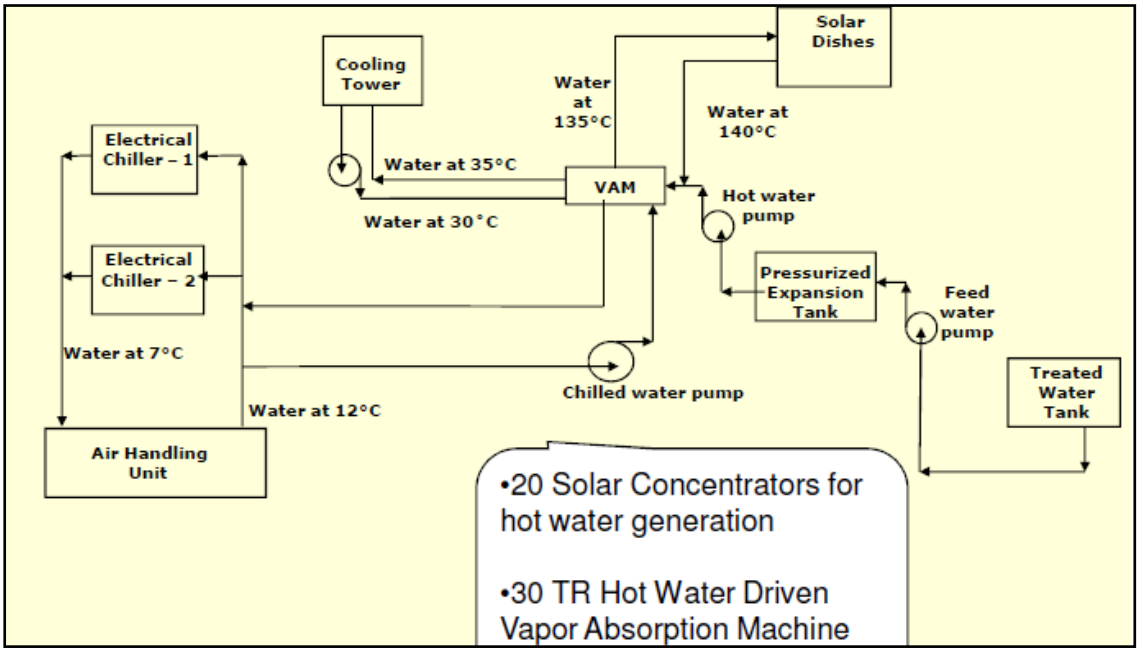
to get the reliable and round the clock chilled water out put through Vapour Absorption Machine by utilization of hot water at 80°C generated through installation of SWHS. However, the chilled water through VAM can also be effectively generated by producing steam or pressurized hot water through Solar Concentrator. In order to ensure uninterrupted supply, solar concentrator can be operated in series with the existing vapour compression machine. Similar systems have been installed by one of the reputed automotive industry to fulfill its process cooling requirement of paint shop area. Schematic of the same is shown in the figure 3.2:



3.1.4 Solar Potential for Comfort Cooling

Various industrial segments have installed centralized or package air conditioning systems to cater the air conditioning requirements of their administrative building, corporate office, control room, R&D laboratory etc. Capacity of the installed air-conditioning unit varies from industry to industry and depending upon the size of the industry. Administration Building & Corporate office requires air conditioning only for eight to ten hours per day. As discussed in the earlier section, it is also possible to install VAR based on solar concentrator to generate chilled water and subsequently air conditioning for the corporate office and administrative office. In fact, installation of VAR based on solar concentrator to cater air conditioning requirement of the corporate and administrative office is easy to integrate and

implement compare to the process cooling requirement considering time during which it requires and availability of sun during the same period. However, commercial Vapour Absorption Systems are available for capacity of 30 TR and above. Hence, it is not possible to implement proposed concept for the office requiring less than 30 TR of air conditioning capacity. Also, installation of VAR based on the solar concentrator system is capital intensive; hence it may not be economical to for the existing establishments to switch. However, industrial unit going for the expansion/new installation may consider incorporation of the same during the design/planning stage only. A schematic of 30 TR pressurized hot water driven VAM, which is used for generation of air conditioning requirement of office building is shown in figure 3.3:



3.1.5 Solar Potential for Hot Air Generation

Industrial segments such as Chemicals, Rice, Pharmaceutical, Pulp &Paperetc. require hot air mainly for the purpose of drying. Temperature requirement of the hot air depends on the types of the dryer as well as moisture content of the material, which is to be dried. For example, pharmaceutical industry utilize fluidized bed dryer to dry the powder which requires hot air or around 60 to 65°C, where as Pulp and Paper industry requires hot air of more than 160°C in the hood to achieve the desired quality and dryness of the paper. In order to generate hot air, different industrial segments use different types of fuels such as

oil, gas, electricity etc. It is possible to generate hot air through installation of Solar Water Heating systems by transferring the heat from the one working fluid (hot water) to another fluid (hot air). However, economics of this option entirely depends on the type of fuel utilized for the generation of hot air in the different industrial segments.

We would like to highlight that we visited around seventy industries from the eight different industrial segments for the primary data collection purpose and collected information pertaining to the above mentioned all five major categories. However, in order to assess potential in the different industrial segments, we have not considered the solar potential through process cooling and comfort cooling. We have also considered areas, which require temperature up to 80°C to assess the realizable market potential in each industrial segment. Overall approach adopted for the assessment of realizable market potential, overview of each industrial segment, scope for integration of SWH and actual realizable market potential for each industrial segment is discussed in the next chapter.

4 APPROACH TO ESTIMATE RELIAZABLE SWH POTENTIAL

Our approach to SWH market assessment is to bring together all the relevant elements that will enable us to undertake market assessment for SWH in the most appropriate manner. While doing this we have ensured that we leverage our experience in executing similar assignments. To get the industry insight and understand the industry process flow, a comprehensive review of the sample industries from each segment has been carried out.

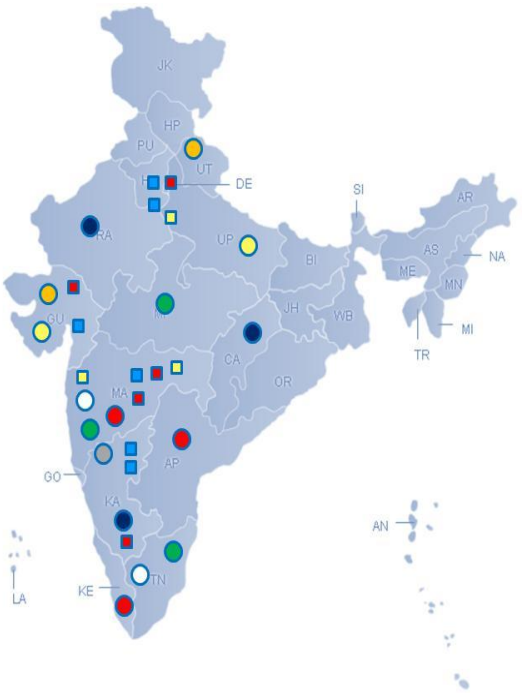
4.1 Mapping of the Industrial Segment

The industry segments and their clusters with potential for SWH applications were mapped under this task. Focus of this task was on the profiling/ mapping of industry segments associated with SWH such as Textile, Food Processing (Dairy, Sea food Processing & Beer Industry, Sugar Industry), Auto componentsincluding electroplating industries, Chemicals, Fertilizer, Pulp and Paper, Pharmaceuticals and drug and rural industries (rice mills etc.), and other industrial applications etc. Different clusters as given in Figure 4.1are covered.

Figure 4.1: Mapping of Industry Clusters for Market Assessment

Industry	Clusters Covered
Textile	Tripur/Maharashtra/MP
Paper & Pulp	Muzaffarnagar /Vapi
Food Processing	Sangli/Kochi/Aurangabad
Auto Component	Coimbatore/Pune/Gurgaon
Chemicals, fertilizer, pharmaceuticals	Baroda/ Dehradun
Rural Industries	Raipur
Sugar	North Karnataka/Sangli

Industry	Locality
SWH Manufacturers	Banglore, Delhi, Chandigarh, Pune, Valsad
EA Agencies	Mumbai,Delhi, Banglore, Vadodara
ESCOs	Mumbai, Pune,Delhi



Profiling was done on the basis of various criteria such as regional spread, industrial clusters, SWH applications etc. This kind of profiling is useful to assess the needs in different industry segments and to gather the issues from various types of stakeholders through field study to be taken up for two clusters in different states for each industry segment.

4.2 Primary data collection and Stakeholder Consultation

To map the interaction between the industry segment and demand side of the SWH with the aim of providing trends which point to the direction and nature of SWH penetration, information for different industry segments was collected through literature survey and interaction with industry experts and solar water heater installers and manufacturers. In addition to this, desktop search was also carried out through web sites of Industry associations, relevant Ministry of each industry segments, annual reports etc. Techno-economic assessment of SWH implementation is carried out based on the data for the industry segment, survey data, technical and cost information available on SWH products, typical pay-back period and key barriers in SWH implementation etc.

Since sector specific SWH application, production, energy data etc, specific to various industry segments is missing, we were required to devote considerable effort in collecting this information through walk-through energy audits / market assessment and data collection. In order to collect data and information, we have used three different types of data collection formats. Following three types of data collection formats as specified in below figure 4.2 was prepared:

Figure 4.2: SWH Market Assessment Data Collection Formats

Primary Data Collection Format:-
Format is prepared to understand the process flow, identify different forms of energy utilized and associated costs, to identify potential areas / equipments for hot water /hot air applications, process and comfort cooling requirements and associated parameters such as temperature range, capacity, present source and its cost etc., to collect the utility details (Boiler, hot water generator etc). This will enable us to realize the overall potential for SWH applications and techno economical potential.

Stakeholder Consultation Format:-
Format is prepared to get the view of SWH manufacturers, Energy Audit agencies, ESCOs about the Services/recommendations provided by them which involves SWH applications in selected industry segments, to identify most Preferred mode of finance for implementation SWH projects, to identify the barriers for implementation of SWH applications in selected industry segments and also their views about SWH technology development, its costs, domestic demand, industry drivers, Future growth prospectus etc.

SWH Case Study Format:-
Format is prepared to capture various aspects of projects implemented such as implementer, objective, project target, technology used, drivers for implementation., barriers addressed, overall effectiveness assessment, applicability of the same project in other industries and detailed cost benefit analysis.

The collected data was analyzed to identify SWH demand drivers and built three scenarios for demand projection-realistic or most likely; optimistic and pessimistic, which are, both, considered less likely. Our estimates in terms of SWH penetration for a given Industry segment under the concerned scenario, recognizes the following,

- Direct and Indirect SWH Applications in Industry Processes
- Type & Cost of fuel used in Industry
- Land Requirement and Availability
- Economics of SWH option
- Temperature range of Hot Water Required

4.3 Estimation of Realizable SWH Potential

Overall SWH Potential specific to each industry segment is estimated after analyzing all the above parameters. Annual production in the base year (FY 2010) was estimated based on the annual production in the previous year and growth rate in the same year. Increase in the annual production year on year was estimated by multiplying the annual production with growth rate in the particular year. Primary data based on primary data collection was analyzed to get the specific hot water requirement per day per unit of annual production. The specific hot water requirement per day was multiplied by annul production in base year (FY 2010) to get the overall hot water requirement (Overall SWH Potential) specific to each industry segment for direct as well as indirect SWH applications.

To get the implementable SWH Potential constrained by space availability, % implementable SWH capacity using the land available with industries assessed in each industry segment was identified. Assuming that the observed pattern of land availability would hold for entire industry segment, this factor '% implementable SWH Capacity' is applied to the Overall SWH potential to get the maximum achievable SWH Potential in each industry segment after considering space constraint. Land requirement for SWH implementation is assessed after considering the average global solar radiation in India and its seasonal variation. It is assumed that the land required will be 1.3 times more than the estimated collector area. Estimation of collector area for 100000 LPD SWHsystem to generate hot water at 80^0C is provided in Table 4.1.

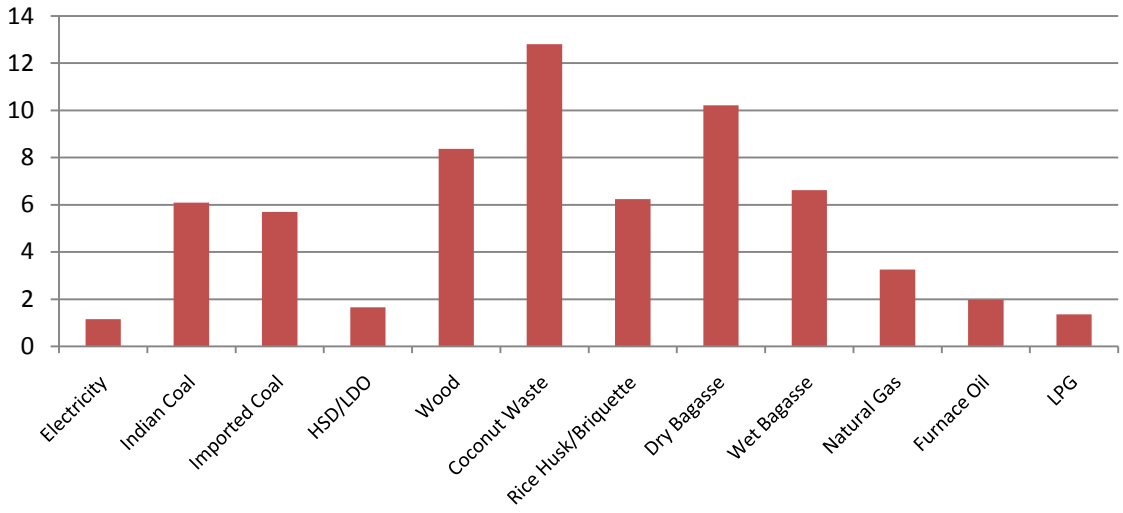
Table 4.1: Estimation of Number of SWH Collectors Required

Month	Water Inlet Temp (Ti)	Ambient Temperature (Ta)	Water Outlet Temperature (To)	Δ_T = (Ti+To)/2 - Ta	Global Solar Radiation kWh/Sq m	Tilt Factor	Solar Insolation, I (kCal/Sq m)	Δ_T /I	Efficiency	Energy Supplied by System (kCal/Sq m)	Water Output / Collector (lit)	No of SWH Collectors
Jan	22	24	80	27	5.317	1.379	6306	0.0343	54%	3425.09	100	997
Feb	24	26	80	26	6.098	1.23	6450	0.0322	55%	3566.87	108	923
Mar	28	30	80	24	6.531	1.046	5875	0.0327	55%	3236.23	106	942
Apr	31	33	80	22.5	6.915	0.898	5340	0.0337	55%	2915.02	102	983
May	31	33	80	22.5	6.99	0.805	4839	0.0372	53%	2559.22	89	1120
Jun	28	30	80	24	5.743	0.812	4010	0.0479	48%	1912.38	63	1594
Jul	26	28	80	25	4.575	0.867	3411	0.0586	42%	1447.96	46	2190
Aug	25	27	80	25.5	4.679	0.894	3597	0.0567	43%	1560.68	48	2071
Sep	25.5	27.5	80	25.25	5.195	0.964	4307	0.0469	48%	2074.13	65	1543
Oct	26.5	28.5	80	24.75	5.603	1.124	5416	0.0366	53%	2881.16	92	1090
Nov	24	26	80	26	5.345	1.311	6026	0.0345	54%	3265.69	99	1008
Dec	22	24	80	27	5.03	1.414	6117	0.0353	54%	3290.92	96	1038
											Average	1124

As indicated in Table 4.1, during the monsoon to get 100000 liters of hot water at 80^0C, the no of collectors required are more because of reduced average global solar radiation. Hence, the number of collectors required is taken as average of remaining 10 months i.e. excluding August and July. Since each collector is of 2 m^2, land requirement to install 1124 no of SWH collectors is 2922 m^2 i.e. 0.73 Acres.

To get the insight about the cost benefit of SWH implementation, simple payback period is assessed for 100000 LPD SWH system to generate hot water of 80^0C after considering different existing fuel sources and its conversion Efficiency. Figure 4.3 indicates the simple payback period (SPP) for different fuel sources after keeping all other parameters (like inlet water temperature, solar radiation etc) constant.

Figure 4.3: Variation in SPP with Different Fuel Sources



As indicated in Figure 4.3, SPP after considering the depreciation benefit and without subsidy for high cost energy sources like Electricity, HSD/LDO, Natural Gas, Furnace Oil, LPG is below three years where as for other energy sources it varies between 5 to 13 years.

Types of the fuels utilised in the different industrial sectors vary depending on availability of the fuel in the region where industry is located. For example, Rice Mills belong to the rural localities with abundant availability of fuel sources like rice husk, wood etc. We collected information with respect to the different types of fuel utilised and its cost . Based on the same % of energy used in different industry segments and cost of energy per million kCal of useful energy (i.e. considering conversion efficiencies) across different industries is evaluated based on the data and is provided in Table 4.2 below:

Table 4.2: Energy Usage across Industry Segments

Energy Form	Unit	kCal/Unit	Cost (Rs/Unit	Efficiency	Industry Segments								
					Dairy	Paper & Pulp	Textile	Rice Mill	Pharmaceutical	Chemicals	Sea Food Industry	Autocomponent Ind.	Beer Industry
Electricity	kWh	860	5.5	95%	14.1%	1.8%	15.5%	1%	39%	23%	39.50%	21.40%	35.81%
Indian Coal	kg	4200	4	75%	0.4%	28.9%	9.6%						26%
Imported Coal	kg	5400	5.5	75%		46.9%	27.9%						
HSD/LDO	lit	10200	38	80%	1.4%		0.6%		47%		60.50%	2.80%	
Wood	kg	3400	2.2	70%	21.1%	9.0%	36.9%						
Coconut Waste	kg	4600	2	72%			9.5%						
ice Husk/Briquett	kg	4200	3.75	72%	0.3%	10.3%		99%		31%			23.40%
Dry Bagasse	kg	4400	2.5	75%									
Wet Bagasse	kg	2200	1.8	70%	34.0%								
Natural Gas	SCM	9500	18.5	82%		3.1%				28%		75.80%	
Furnace Oil	Lit	9800	30	78%	28.5%					18%			14.80%
LPG	kg	11400	52	80%	0.1%				14%				
Cost of Energy Per Million Kcal of Useful Energy (Rs/MkCal)					2742	1409	1973	1295	5619	3307	5477	3371	3612

As indicated in Table 4.2, % of high cost energy sources like electricity, natural gas, furnace oil, LPG and HSD/LDO is more in Sea Food Industry, , Pharmaceutical, Beer, Auto Component Industries, Chemical Industries and Dairy Industries. Industrial sectors such as Pharmaceutical and Dairy need to maintain good hygiene condition. In order to fulfil this requirement, these industries are using high cost energy sources such as electricity, natural gas, LPG etc. in their processes. For pharmaceutical industry entire 100% energy sources are high cost energy sources, whereas for chemical and dairy industry it is 70% and 44%. This has resulted in higher energy cost per million kCal (MkCal) of useful energy. Thus for pharmaceutical industry energy cost is 5619 Rs/MkCal followed by Sea food processing (5477 Rs./MKcal), Beer Industry (3612 Rs./MKcal), chemical (3307 Rs/MkCal) and Auto Component Industry (3371Rs/MkCal). Hence, SWH applications in these industries will minimize the fuel cost in near term and therefore SWH will be economically viable in these industrial sectors.

In addition to this, the requirement of hot water temperature also affects the SWH penetration across the industry segments. If the required hot water temperature is lesser than 80^0C, it can be achieved with less number of solar collectors and with better reliability. This increases the chances for SWH penetration and vice versa.

All these parameters such as availability of land and cost of useful energy across the various industry segments are provided in Table 4.3 below.

Table 4.3: Different Parameters Impacting SWH Penetration

Parameters	Industry Segments								
	Dairy	Paper & Pulp	Textile	Rice Mill	Pharmaceutical	Chemicals	Sea Food Industry	Autocomponent	Beer Industry
Space Constraint (Posible Implementable SWH potential after considering Land Availablility)	54.6%	22.5%	35.2%	58.9%	66.3%	45.3%	53.0%	54.52%	43.06%
Cost of Energy Per Million Kcal of Useful Energy (Rs/ MkCal)	2742	1409	1973	1295	5619	3307	5477	3371	3612

As indicated in Table 4.3, for pharmaceutical industry, implementable SWH potential after considering land availability and cost of energy per million Kcal of useful energy is maximum 66.3% and 5619 Rs./MKcal respectively. Based on the analysis of these

parameters, we have made certain assumptions in order to estimate realisable SWH potential in three different scenarios such as Optimistic, Pessimistic and Realistic. Considering the maximum Space availability for the installation of SWHS (66.3%) and highest cost of energy per Million Kcal of useful energy (5619) in Pharmaceutical sector, we have considered maximum penetration (100%) of SWHS in Pharmaceutical Industry. We have estimated maximum SWH penetration for the other Industrial Sector in comparison with Pharmaceutical Industry. We have also assumed maximum and minimum penetration of 40% and 25% of total implementable SWH potential in Optimistic and Pessimistic scenarios respectively in next twelve years and same has been considered for the Pharmaceutical Industry. We have also taken average value of Optimistic and Pessimistic scenario(32.5%) in order to estimate penetration of SWH in the Realistic Scenario over the period of twelve years. Similarly, we have estimated % of maximum SWH potential for three different scenarios for all industrial sectors in comparison with pharmaceutical industry. Percentage estimated for each industrial sector has been divided equally in twelve years and the same has been utilised in order to estimate year on year increase in SWH penetration. Table 4.4 below shows the SWH penetration assumptions for different industry segments under different scenarios.

Table 4.4: SWH Penetration for Different Industry Segments under Different Scenarios

Parameters		Industry Segments								
		Dairy	Paper & Pulp	Textile	Rice Mill	Pharmaceutical	Chemicals	Sea Food Industry	Autocomponent	Beer Industry
Overall SWH penetration (Direct + Indirect) over the span of 12 years under different scenarios	P	12.2%	6.3%	8.8%	5.8%	25.0%	14.7%	24.4%	15.0%	16.1%
	O	19.5%	10.0%	14.0%	9.2%	40.0%	23.5%	39.0%	24.0%	25.7%
	R	15.9%	8.1%	11.4%	7.5%	32.5%	19.1%	31.7%	19.5%	20.9%

We have provided the overview of the various industry segments with possible scope for SWH integration in different industrial processes in the subsequent chapters of this report. Solar thermal systems are particularly effective in industries that require water temperature in the range 60–80°C. Major industrial sectors that can be distinguished for promising potential for large solar thermal systems are Food Processing Industry (Dairy Sector, Beer Industry, Sea Food Processing Industry, Sugar Industry etc.), Pharmaceutical Industry, Textile Sector, Rice Mill sector, Pulp and Paper and Chemical Industry. Each of these industry segment is analysed for the integration of SWHS to meet the partial thermal energy demand. Based on the same, we have estimated realizable market potential for each industrial sector and have development SWH potential scenario in the subsequent chapters separately.

5 SWH POTENTIAL IN FOOD PROCESSING INDUSTRY

5.1 Introduction

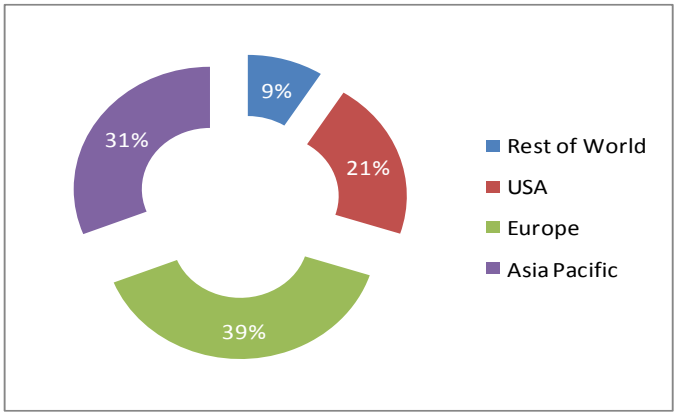
The contribution of agriculture to India's GDP at the time of Independence was 70% and it accounted for 85% of total employment. At present, the contribution of agriculture to GDP is about 18%, but it still engages about 70% of the population. The country has a huge potential of growth in agriculture with about 184 million hectares of arable land and diverse agro climatic conditions, suitable for cultivation of a wide variety of crops. Naturally, agro based industry has good potential in the country. Presently, the Processed Food Industry is divided into following broad segments:

- Primary Processed Food – which includes products such as fruits and vegetables, packed milk, unbranded edible oil, milled rice, flour, tea, coffee, pulses, spices, and salt, sold in packed or non-packed forms.
- Value-added Processed Food – includes products such as processed fruits &vegetables, juices, jams, pickles, squashes, dairy products (ghee, paneer, etc), processed poultry&marine products, confectionary, chocolates, alcoholic beverages.

5.2 Global Food Processing Industry

The Global Processed Food Industry is valued at US $ 3.2 trillion and accounts for over 3/4th of global food sales. Despite the large size of the industry, only 6% of the processed food is traded the world over as compared to bulk agricultural commodities where 16% of produce is traded. The USA is the single largest consumer of processed food and accounts for 31% of the global sales. This is because as countries develop, high quality and value-added processed food such as convenience food is preferred over staples, which are prevalent in less developed economies.

Figure: 5.1 Major Markets for sale of processed food



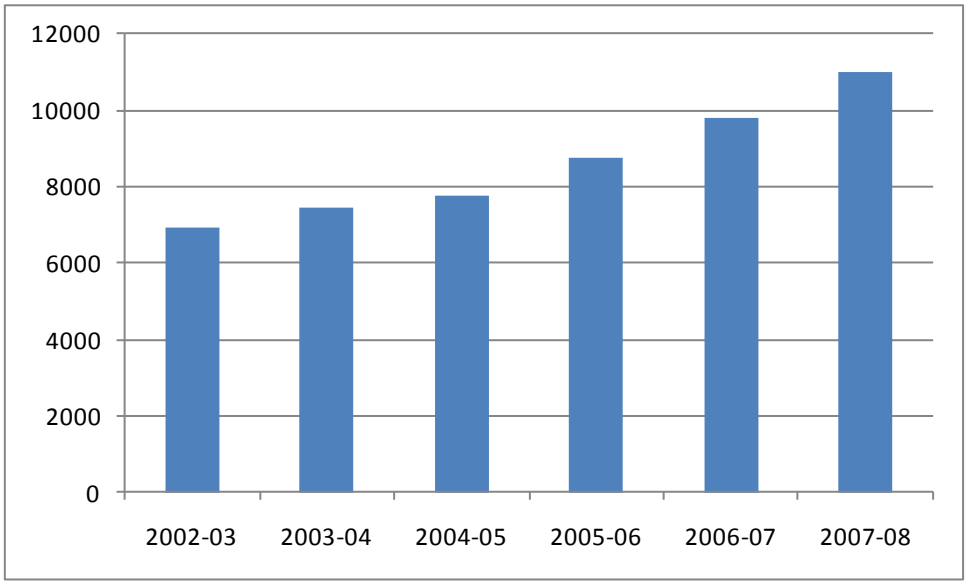
Source: FICCI Knowledge Paper on "Processed food and Agribusiness"

The share of India in the global processed food trade is currently meagre 1.6%. Ministry of Food Processing Industries has stated in its Vision 2015 that it aims to increase India's share from the current level to 3% of world processed food trade.

5.3 India's Food Processing Industry

The size of India's Food Processing Industry in 2008 was over Rs. 3,600 billion (US $ 72 billion). The overall consumption in food, as measured by PFCE, is about Rs. 19,000 billion (US $ 220 billion). The PFCE on food has registered a Compounded Annual Growth Rate (CAGR) of 9.8% between 2003 and 2008. As per the Annual Report of Ministry of Food Processing Industry for the year 2009-10, food processing sector contributed over 14% of manufacturing GDP with a share of Rs 2,80,000 crores.

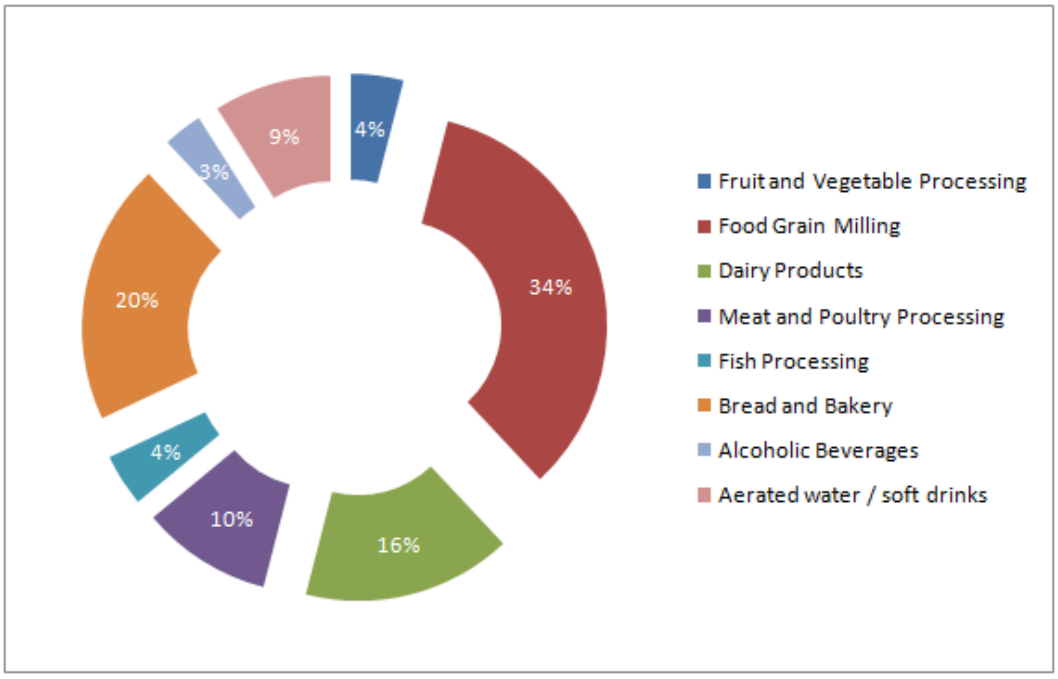
Figure: 5.2: PFCE in Food in India (Rs. billion)



Source: CSO and IMaCS analysis

The major segments in the Food Processing sector are Fruits and Vegetables, Dairy, Edible Oils, Meat and Poultry, Non-alcoholic beverages, Grain-based products, Marine products, Sugar and sugar-based products, Alcoholic beverages, Pulses, Aerated beverages, Malted beverages, Spices, and Salt. Out of these segments, Dairy (16%), Grain-based Products (34%), Baker-based products (20%), and fish and meat products (14%) contribute to a major portion of industry revenues, apart from the manufacture of beverages.

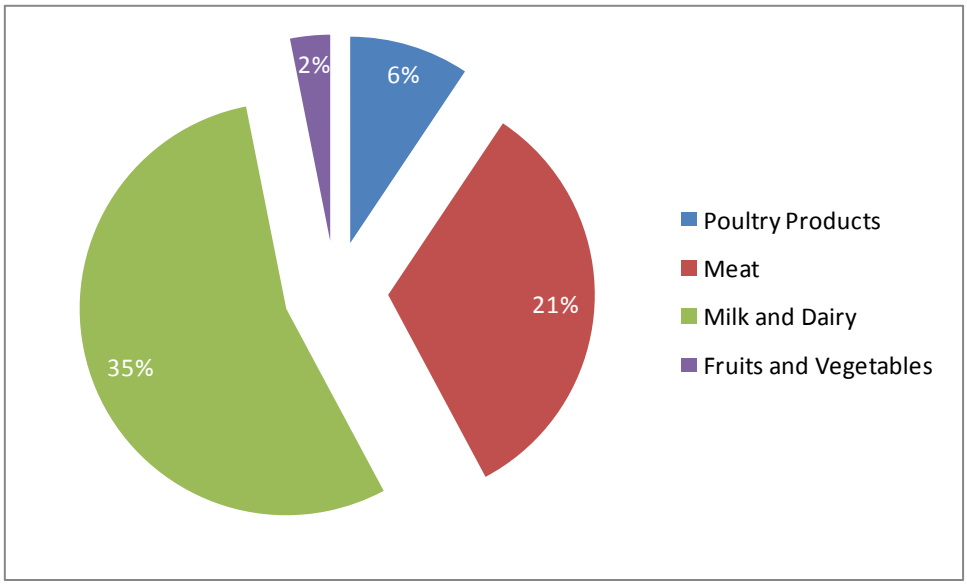
Figure: 5.3 Major Segments in the Food Processing Industry



Source: Annual Survey of Industry (ASI), MOFPI

The level of processing in India is low compared to international levels. Processing of agriculture produce is around 40% in China, 30% in Thailand, 70% in Brazil, 78% in the Philippines and 80% in Malaysia.

Figure 5.4: Level of processing in India in select segments



Source: MOFPI

The major States in India where food processing is carried out are Andhra Pradesh (13.4% of India's Food Processing Industry, and a centre for fruits, vegetables and grains), Gujarat (12.7%, and a centre for edible oils and dairy), Maharashtra (14%, and a centre for fruit, vegetables, grains and beverages) and Uttar Pradesh (12%, across almost all product categories).

The Government has also taken steps to provide financial assistance for setting up and modernising food processing units, creation of infrastructure, and support for R&D and human resource development in addition to other promotional measures to encourage the growth of the processed food sector. The government' vision for the sector includes:

- Promoting a dynamic food processing industry;
- Enhancing the competitiveness in domestic and international market,
- Making sector attractive for both domestic and international market,
- Achieving integration of food processing infrastructure from farm to market,
- Level of processing of perishable from 6% to 20%;
- Value addition from 20% to 35%
- Share in global food trade from 1.5% to 3% by 2015;

The major segments are Food Grain Milling, Dairy Products, Fish Processing and Alcoholic Beverages, which together constitute about 67% of total industry revenue. We have carried out detailed assessment of abovementioned sub-sectors of food processing industry and the same is presented in the subsequent sections.

5.4 Dairy Industry

The dairy products form the most important component of the Indian food system. Milk, being a nutritious but perishable food, needs proper preservation techniques that can be used at a small scale to extend its shelf life. Hence in India, dairy industry is largely driven by the local processing facilities. Traditionally this has encouraged the development of cooperatives as a means to alleviate the vulnerability of dairy farmers as cooperative rules usually require the compulsory purchase of all members' product. By pooling their resources and operating their collectively owned dairy, farmers are able to minimize their market risk. Changes to technologies and transport over time have challenged these patterns, creating dilemma for dairy cooperatives.

5.4.1 Overview of Dairy Industry in India

India has the highest livestock population in the world with 50% of the buffaloes and 20% of the world's cattle population, most of which are milk cows and milk buffaloes. India's dairy industry is considered as one of the most successful development programmes in the post-Independence period.

In FY 2006-07, the total milk production in the country was over 100869 thousand tonnes with and grows to around 113100 thousand tonnes in FY 2009-10. The industry had been recording an annual growth of around 4% during the period 1993-2005, which is almost 3 times the average growth rate of the dairy industry in the world. The growth is still continuing at the rate of 4% during the period 2006-2010. Milk processing in India is around 35%, of which the organized dairy industry account for 13% of the milk produced, while the rest of the milk is either consumed at farm level, or sold as fresh, non-pasteurized milk through unorganized channels.

According to Dairy India 2007 estimates, the current size of the Indian dairy sector is US$ 62.67 billion and has been growing at a rate of 5% a year. As per National Dairy Development Board, India's milk production in FY 2008-09 is estimated as 108 million tones and continues to be the largest producer of milk in the world since 1988[2]. India's modern dairy sector has expanded rapidly over the last few years. From an insignificant 0.2 million lpd of milk being processed in the year 1951, the organized sector is presently handling around 20 million lpd in over 400 dairy plants. As per the Ministry of Food Processing Industry, the dairy sector ranks first in terms of processed foods with 35% of the produce being processed every year. Production of milk in different States since year 97-98 is provided in the following table5.1:

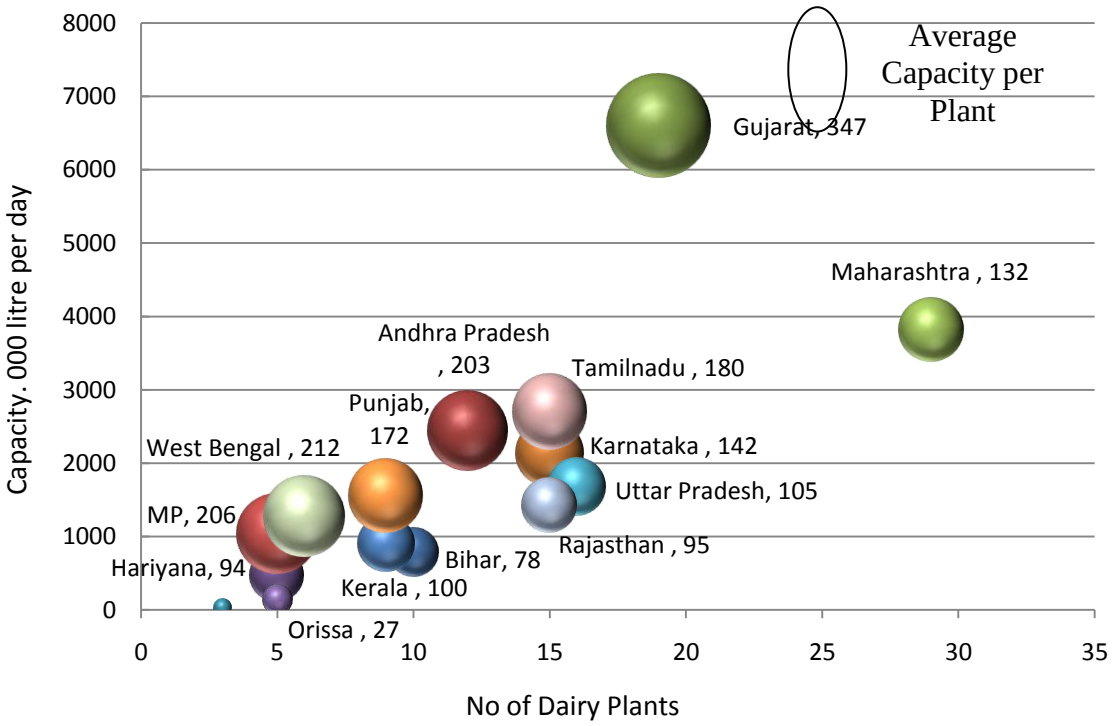
[1] www.indiastat.com
[2] www.ibef.org, accessed as on 2nd April, 2010

Estimated Milk Production in India (000 tonnes)												
State	FY 97-98	FY 98-99	FY 99-00	FY 00-01	FY 01-02	FY 02-03	FY 03-04	FY 04-05	FY 05-06	FY 06-07	FY 07-08	FY 08-09
All India	72128	75424	78286	80607	84406	86159	88082	92484	97066	100869	104840	108463
Andhra Pradesh	4473	4842	5122	5521	5814	6584	6959	7257	7624	7939	8925	9570
Arunachal Pradesh	43	45	46	42	42	46	46	48	48	49	50	24
Assam	719	725	667	683	682	705	727	739	747	751	752	753
Bihar **	3420	3440	3454	2489	2664	2869	3180	4743	5060	5450	5783	5934
Goa	38	41	44	45	45	46	48	57	56	57	58	59
Gujarat	4913	5059	5269	5312	5862	6089	6421	6745	6960	7533	7911	8386
Haryana	4373	4527	4679	4850	4978	5124	5221	5222	5299	5367	5442	5745
Himachal Pradesh	714	724	742	761	756	773	786	870	869	872	874	884
J & K	1167	1232	1286	1321	1360	1389	1414	1422	1400	1400	1498	1498
Karnataka	3970	4231	4471	4599	4797	4539	3857	3917	4022	4124	4244	4538
Kerala	2343	2420	2532	2605	2718	2419	2111	2025	2063	2119	2253	2441
Madhya Pradesh	5377	5442	5519	4761	5283	5343	5388	5506	6283	6375	6572	6855
Maharashtra	5193	5609	5707	5849	6094	6238	6379	6567	6769	6978	7210	7455
Manipur	62	65	68	66	68	69	71	75	77	77	78	78
Meghalaya	59	61	62	64	66	68	69	71	73	75	77	77
Mizoram	17	20	18	14	14	15	15	16	15	16	17	17
Nagaland	46	48	48	51	57	58	63	69	74	67	45	53
Orissa	672	733	850	876	929	941	997	1283	1342	1431	1625	1672
Punjab	7165	7394	7706	7777	7932	8173	8391	8554	8909	9168	9282	9387
Rajasthan	6487	6923	7280	7455	7758	7789	8054	8310	8713	9375	9536	9491
Sikkim	35	35	35	35	37	45	48	46	48	49	49	49
Tamil Nadu	4061	4273	4586	4910	4988	4622	4752	4784	5474	5560	5586	5673
Tripura	57	76	77	77	90	79	84	86	87	89	91	96
Uttar Pradesh	12934	13618	14152	13857	14648	15288	15943	16512	17356	18095	18861	19537
West Bengal	3415	3441	3465	3471	3515	3600	3686	3790	3891	3982	4087	4176
A&N Islands	22	22	23	22	23	26	25	24	20	23	24	26
Chandigarh	43	43	42	43	43	43	44	43	46	46	47	47
D&N Haveli	4	8	8	8	8	8	8	4	5	5	5	4
Daman & Diu	1	1	1	1	1	1	1	1	1	1	1	1
Delhi	267	290	290	291	294	296	299	303	310	289	282	285
Lakshadweep	1	2	1	2	2	2	1	1	2	2	2	2
Pondicherry	36	36	37	37	37	37	40	41	43	45	46	46
Chhattisgarh	-	-	-	777	795	804	812	831	839	849	866	908
Uttaranchal	-	-	-	1025	1066	1079	1188	1195	1206	1213	1221	1230
Jharkhand												

A specific Indian phenomenon is the unorganized sector of milkmen, vendors who collect milk from local producers and sell the milk in both, urban and non-urban areas, which handles around 65-70% of the national milk production. In the organized dairy industry, the cooperative milk processors have a 60% market share. The cooperative dairies process 90% of the collected milk as liquid milk and rest 10% as other dairy products whereas the private dairies process and sell only 20% of the milk collected as liquid milk and 80% as other dairy products with clear focus on value-added products.

India has around 70,000 village dairy co-operatives, 22 co-operative dairy federations at state level & 170 milk producer unions at district level. Under organized dairy sector, number of plants with total capacity in thousand litre per day for 15 major state co-operative dairy federations is provided in figure 5.5 below:

Figure 5.5: Overview of Major Co-operative Dairy Federations in India[3]



As indicated in 5.5, Gujarat is a major milk producer with capacity of 8386 thousand litres per day (000' lpd) followed by Maharashtra (7455), Tamil Nadu (5673) and Andhra Pradesh (9570). Average milk production capacity in 000' lpd per plant is higher in Gujarat,

[3] Source: http://www.nddb.org, accessed on 8th April, 2010

Maharashtra, AP, MP, Punjab, Tamil Nadu etc. Uttar Pradesh, Punjab, Haryana, Rajasthan, Gujarat, Maharashtra, AP , Karnataka and Tamil Nadu are the milk surplus states [4].

Amul, Nestle, Mother Dairy, Haldiram, Paras Dairy, Vijaya, Vadilal, HLL, Bikanerwala are some of the leading brands in dairy sector. One of the world's largest liquid milk plants of Mother Dairy is located in Gujarat, handling over 1 million lpd. This is India's first automated dairy plant. It is owned by India's biggest dairy cooperative group, Gujarat Cooperative Milk Marketing Federation (GCMMF) in Anand, with an annual turnover in excess of Rs 23 billion. Amul Industries with its satellite dairies with total installed capacity of 1.5 million lpdis also one of the leading dairy industry player.

India's first vertical dairy (capacity: 400,000 lpd), owned by the Pradeshik Cooperative Dairy Federation (PCDF) has been commissioned at Noida, outside Delhi. Majority of Indian dairy industries are characterized as labour intensive and not automated, this results in lesser milk processing than international averages but also lower costs due to cheap labour as compared to other developed countries.

Recognizing the importance of the dairy sector, several programmes have been taken up by the Government, of which ones are intensive cattle development projects, crossbreeding projects through bilateral assistance and technology mission by establishing National Dairy Development Board (NDDB). It was created in 1965 to promote, finance and support producer-owned and controlled organizations. NDDB's programme and activities seek to strengthen farmer cooperatives and support national policies that are favourable to the growth of such institutions. Fundamental to NDDB's efforts are cooperative principles and cooperative strategies.

North Gujarat Dairy Cluster: Gujarat is a leading state for milk production in the country. North Gujarat is one of the major hubs in milk processing. Asia's second largest dairy 'Dudhsagar Milk Cooperative Dairy' and largest market yard 'Unjha' are located in Mehsana. At village level 12,057 Milk Co- operative societies, 43 chilling centers, and 13 Dairy processing units at district level (Dairy) are functioning in the state. On an average the total milk collected is 76.49 Lakh Liters per day (LLPD), which is being processed. In North Gujarat 7-8 processing units currently exist. Maximum units are functioning for last 15 to 20 years with expansions as well as modernization. Some units are also running on contract

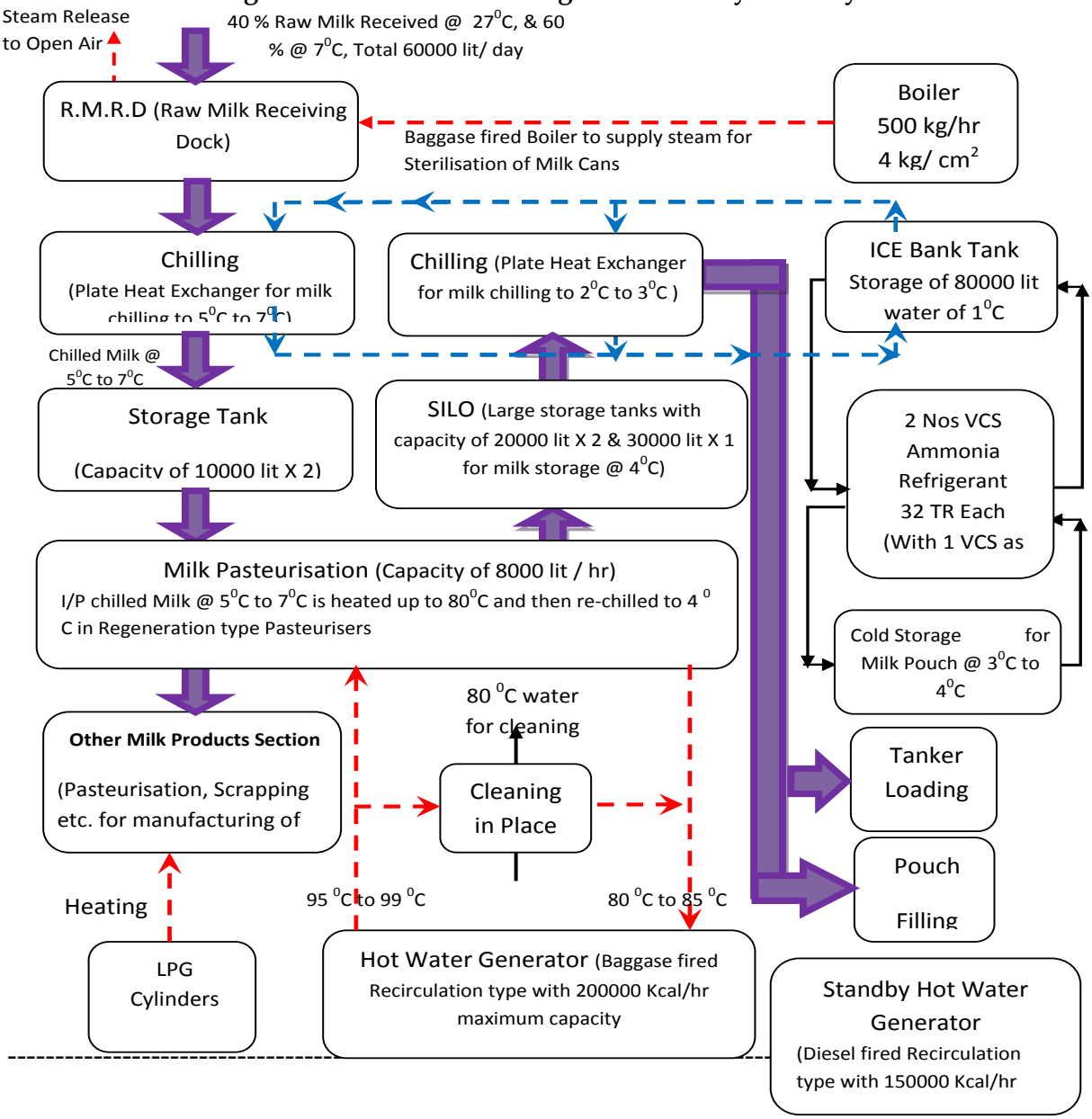
[4] Ministry of food Processing Industries, GoI

basis for AMUL. Milk is collected from local villages / milk co-operative societies. The processing units are working round the clock. The Dairy cluster is not coming under the SME category as the minimum processing plant cost is approximately Rs. 40 to Rs. 50 crores.

5.4.2 Dairy Industry Process and Integration of SWHS

Dairy industry process can be divided into two major sections namely liquid milk pasteurization (Milk Market Based Industry) and processing industry for value added products like butter, ghee, skimmed powder, cheese etc (Milk Product Based Industry). Milk and cream are separated in the separator and skim milk is stored for further processing to powder. Cream is converted to butter and ghee. Process flow diagram for typical dairy industry is provided in figure 5.6 below.

Figure: 5.6 Process Flow Diagrams for Dairy Industry



As indicated in figure 5.6, milk processing industry involves energy usage mainly for cooling of fresh milk and then to heat it (Pasteurizing) to destroy both contaminating micro-organisms and naturally occurring enzymes that change the flavour of milk. In Indian context there are rural societies where milk is collected and cooled at 4 to 6^0C (to avoid milk from getting spoilt) before transporting it to dairy for processing.

Since all the milk is collected during the morning and evening periods, milk pasteurizing capacities at cooperatives are not sufficient. Also during transport temperature of milk again goes up, hence collected milk is stored in storage tanks after cooling it to 4 to 5 ^{0}C to extend the shelf life by a day or two. Cooling does not destroy bacteria or enzymes but it slows down their activity. Cooled raw milk keeps its quality for a few days before it is processed.

The milk from storage tank is then heated to 72 to 78^0C during Pasteurization process, which consumes a lot of thermal energy. Thus the energy cost contributes to 30-35% in overall processing costs. Energy in the form of coal, furnace oil and electricity is utilized by the dairy industry.

Energy consumption (Electrical & Thermal) in dairy industry is largely governed by parameters like, milk processing capacity, type and age of machinery i.e. type of Compressors, refrigeration system, boilers etc, plant modernity, fuel quality and composition and final products energy use depends on only milk processing and value addition like butter, ghee, yogurt, ice cream etc.

Thermal energy (in the form of steam) is utilized in pasteurization and powder plant whereas electricity is mainly consumed in refrigeration. Ratio of thermal and electrical energy depends on the product mix where as overall energy usage depends on only milk processing and value added products like milk powder, butter, ghee, yogurt and ice cream etc. However thermal energy requirement in the dairy industry can be replaced partially by means of SWHS.

Milk being perishable food item, to maintain the hygiene, a huge quantity of hot water is used for cleaning and washing purpose. Thus in Dairy industry large quantity of hot water with temperature range of 60 to 80^0C is used for direct heating applications such as to rinse

and wash the milk cans and milk tankers. This hot water requirement can be directly met through SWHS.

In addition to this, within dairy industry there is scope for integration of SWH based hot water for milk pasteurization process (Indirect heating) depending upon the technology. The modern technologies allow usage of 80^0C hot water instead of steam.

5.4.3 Realisable SWH Potential in Dairy Industry

Dairy industry has direct as well as indirect SWH applications. As direct application, SWH can be used for boiler makeup water heating as well as for cane and tank washing. As indirect application, SWH can be integrated with milk pasteurization process with modern dairy technologies. We visited five dairy industries located in Pune, Maharashtra in order to estimate the overall SWH potential for the five major categories of applications defined earlier.We have also calculated the land requirement for the installation of SWHS systems to realise the overall potential. Information related to the land availability of particular industry also collected during the market assessment survey of that particular industry. Based on the same, maximum implementable SWH potential after considering the space constraint is accessed for each industry. Data collected for the dairy industries through market assessment survey is provided in Table 5.2 below:

Table 5.2: Hot water requirement in Dairy Industry and Land availability

Industry Name		Hutatma Sahakari Doodh Utpadak Sangh Limited	Rajarambapu Sahakari Doodh Sangh Limited	Shri Warna Sahakari Doodh Utpadak Sangh Limited	M/s. B.G. Chitale Dairy	Shri Hanuman Sahakari Doodh Vyavasaik & Krishiutpadak Seva Sanstha Maryadit	Overall Parameters
Co-Generation Status		No	No	No	No	No	
Production (Lit/ Annum)		21900000	68594263	155000000	127750000	2447323	751383172
Solar Potential For Boiler Feed Water Heating & Direct Hot water	Temp (0C)	80	80	80	60-75	80	75-80
		80	80	80	60-75	80	75-80
	Hot Water	16320	71400	500000	60000	31000	678720
Solar Potential For Process Heating	Temp (0C)	95	95	High Temperature & Pressure Steam is used	83	High Temperature & Pressure Steam is used	83-95
		80	80		80		80
	Hot Water	49005	160000		286291		495296
Overall Swh Potential For Industries Surveyed		65325	231400	500000	346291	31000	1174016
Estimated Land Requirement for SWH Installtion (Acres)		0.52	1.83	3.95	2.74	0.24	9.28
Land Available for SWH installation		1	2	1	1.5	2	7.5
Maximum Implementable SWH Potential After	SWH Capacity	65325	231400	126533	189799.5	31000	644057.5
	% of Total Potential	100.0%	100.0%	25.3%	54.8%	100.0%	54.86%

Source: ABPS Infra Research & Analysis

In addition, we also collected data for different types of fuels used in each of the abovementioned dairy plants and the same is provided in Table 5.3 below:

Table 5 .3: Different Types of Fuels Used in Dairy Industry

Industry Name		Hutatma Sahakari Doodh Utpadak Sangh Limited		Rajarambapu Sahakari Doodh Sangh Limited		Shri Warna Sahakari Doodh Utpadak Sangh Limited		M/s. B.G. Chitale Dairy		Shri Hanuman Sahakari Doodh Vyavasaik & Krishiutpadak Seva Sanstha Maryadit		Overall Parameters	
Energy Utilised From Different energy Sources (Million kCal)	Energy Source	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total
	Electricity	516.0	98.4%	1889	30.6%	11965	13.0%	2197	12.6%	258	10.4%	16,825	14.1%
	Indian Coal					513	0.6%					513	0.4%
	FO			4159	67.4%	14478	15.7%	15288	87.4%			33,925	28.5%
	Bagasse					40405	43.7%					40,405	34.0%
	Wood					24643	26.7%			510	20.5%	25,153	21.1%
	Briquette					389	0.4%					389	0.3%
	LPG	6.8	1.3%							68	2.7%	75	0.1%
	LDO/HSD	1.5	0.3%	122	2.0%					1530	61.5%	1,654	1.4%
	Solar							Yes		122			
	Total	524	100%	6170	100%	92394	100%	17485	100%	2488	100%	118,940	100%

Source: ABPS Infra Research & Analysis

It can be seen from the above table 5.3 that dairy units utilise almost all types of fuels to meet energy requirement of their manufacturing processes. We have estimated specific hot water requirement per day per unit of production for five industries. Data provided in table 5.2 &5.3 is analyzed to generate different projection scenarios (realistic, optimistic and pessimist) for both direct hot water applications as well as indirect hot water applications. We have also considered annual growth rate of the dairy processing industry for the next twelve years and estimated maximum possible SWH penetration over the next twelve years under the realistic scenario and same is provided in table 5.4 below:

Dairy Industry- SWH Potential Scenario	Realistic Scenario	
All India Annual Milk Production in Base Year FY 2008-09	LPD	1.20514E+11
% of Milk Production being processed	%	35%
Dairy Industry Growth Rate in India in FY 2009-10	%	4.25%
Hot water Requirement per day for Direct application per lit of milk processed Annually	LPD	0.0016
All India Annual Capacity of Milk Processing Industry in Base Year FY 10	Lit/Annum	43972993993
Overall Hot Water Requirement for Direct Applications in Dairy Industry in FY 10	LPD	69061971
Dairy Industry Growth Rate in India for the period FY 2011 to FY 2022	%	4.25%

SWH Scenario For Dairy Industry			1	3	5	6	7	9	11	12
			FY11	FY13	FY15	FY16	FY17	FY19	FY21	FY22
ALL India Milk Processing Industry Capaci	Year On Year	Lit/Annum	45841846238	49821205003	54145996980	56447201851	58846207930	63954426567	69506070508	72460078505
All India Hot Water Requirement in Milk Processing Industry	Year On Year	LPD	71997104	78246903	85039223	88653390	92421159	100443894	109163051	113802481
All India Hot Water Requirement considering space constraints	Year On Year	LPD	39293913	42704870	46411920	48384426	50440764	54819338	59577999	62110064
Year Wise % SWH penetration in Realistic Scenario	Year On Year	%	1.32%	1.32%	1.32%	1.32%	1.32%	1.32%	1.32%	1.32%
	Cumulative	%	1.32%	3.97%	6.61%	7.93%	9.25%	11.90%	14.54%	15.86%
Maximum Achievable SWH Penetration in Realistic Scenario	Year On Year	LPD	519347	564429	613425	639496	666674	724546	787441	820907
	Cumulative	LPD	519347	1625194	2827037	3466532	4133206	5552760	7095539	7916446
		M2	12629	39520	68746	84296	100508	135028	172544	192506

Source: ABPS Infra Research & Analysis

Overall realisable SWH potential for Dairy Industry in terms of LPD and Square Meter of the collector area required for next twelve years under realistic, optimistic and pessimistic scenarios has been calculated and the same is presented in table 5.5 below:

Table5.5: SWH Potential Scenarios in Dairy Industry

		FY13	FY17	FY22
Realistic Scenario	LPD	1625194	4133206	7916446
	M^2	39520	100508	192506
Optimistic Scenario	LPD	1745044	4253056	8036295
	M^2	42434	103422	195420
Pessimistic Scenario	LPD	1505345	4013357	7796597
	M^2	36605	97593	189591

From the above table, it can be seen that cumulative overall realisable SWH market potential will be 192506 square meter of the collector area in the FY 2022 under the realistic scenario (most likely). We have also estimated state wise SWH potential in dairy industry by applying % of state wise milk production to the all India SWH potential under realistic scenario. States like Uttar Pradesh, Punjab, Maharashtra, Madhya Pradesh, Gujarat, Bihar, Rajasthan and Andhra Pradesh offers more than 70% of the all India realisable SWH potential in the dairy sector. State wise realisable SWH market potential for the dairy sector in India is provided in overall Industrial SWH potential section.

5.5 Seafood Processing Industry

5.5.1 Overview of Seafood Processing Industry in India

India with its very long coastline enjoys a natural advantage in the marine food sector. India is the third largest fish producing country in the world and ranks second in inland fish production. The 8,000 km coastline, 3 mn hectares of reservoirs, 1.4 mn hectares of brackish water, 50,600 sq km of continental shelf area and 2.2 mn sq km of exclusive economic zone

supplement India's vast potential for fishes. Against an estimated fishery potential of 3.9 million tonnes from marine sector, only 2.6 million tonnes are tapped.

Fishing efforts are largely confined to the inshore waters through artisanal, traditional, mechanised sectors. About 90% of the present production from the marine sector is from within a depth range of up to 50 to 70 meters and remaining 10% from depths extending up to 200 meters. While 93% of the production is contributed by artisanal, mechanised and motorised sector, the remaining 7% is contributed by deep sea fishing fleets confining their operation mainly to the shrimp grounds in the upper East Coast.

There are about 1273 registered exporters in the country. Indian seafood processing industry is quite developed with 399 processing plants around the country. There are about 371 freezing plants, and 471 cold storages with storage capacity of around 89258 tonnes. Around 95% of the sea food processing units in the country are concentrated in the 20 major clusters in twelve maritime States where fish catches is the highest. These States are Kerala, Maharashtra, Tamil Nadu, Gujarat, Pondicherry, West Bengal, Karnataka, Orissa, Andhra Pradesh, Goa, Andaman & Nicobar Islands and Lakshadweep. Following table 5.6 provides the information related to number of exporters, no. of processing plants, freezing capacities, number of cold storages, its storage capacity and number of fishing vessels in the above mentioned states.

Table 5.6: Marine States of India & Installed Capacity

States	Number of Exporters	No. of Process Plants	Freezing Capacity (T/D)	No. of Cold Storages	Storage Capacity	No. of Fishing Vessels
Kerala	287	124	1585.77	169	23086.5	2963
Tamil Nadu	286	48	524.55	67	5900	1562
Karnataka	43	14	186.4	26	3540	3226
Andhra Pradesh	95	52	779.5	53	7200	717
Goa	9	7	104	9	1275	420
Gujarath	64	55	2216.03	57	22925	426
Orissa	30	21	220	20	2460	414
Maharastra	268	41	1327.11	39	19372	2932
West Bengal	99	37	340	30	3500	0
Delhi (UT)	92	--	0	1	15	0

Source: The Marine Products Export Development Authority

Till the end of 1960, export of Indian marine products mainly consisted of dried items like dried fish and dried shrimp. Although frozen items were present in the export basket from 1953

onwards in negligible quantities, it was only in 1961 the export of dried marine products was overtaken by export of frozen items leading to a steady progress in export earnings. Before 1960, the markets of Indian marine products were largely confined to neighbouring countries like Sri Lanka, Myanmar, and Singapore etc. This situation changed with the development of technology/modernization; dried products gave way to canned and frozen items. Several seafood processing units with modern machinery for freezing and production of value added products were set up at all important centres in the country for export processing. The export of marine products has steadily grown over the years from a mere 15732 tonnes in 1961-62 to 602835 tonnes in the year 2008-09. Marine products account for approximately 1.1% of the total exports from India. All export oriented processing units are HACCP certified. Processed fish products for exports include conventional block frozen products, individual quick frozen products, minced fish products like fish sausage, cakes, cutlets, pastes, surimi, texturised products, dry fish, etc.

Marine products have created a sensation in the world market because of their high health attributes. With the high unit value, seafood has been acclaimed as one of the fastest moving commodity in the world market. The world market for seafood has doubled during the last decade and India's share is around 2 to 3%. Dependence on shrimp as a product is changing due to the increased attention give to other fisher resource like squid, cuttlefish, fin fish, etc.

In view of over exploitation and mounting operational costs of the fishing industry in the country, the focus areas are future management and conservation of resources, diversification of fishing effort and economic utilization of fishing units. The players are required to obtain Hazard Analysis Critical Control Point (HACCP) certification for its plants and also update the processing technology and quality assurance in accordance with the requirements of international institutions formulating quality systems such as Codex Alimentarius Commission. The table 5.7 below presents the major players in the industry with key brands and products.

Table 5.7 Major Players of the industry with key brands and products

Companies	Key Brands	Key Products
Allanasons	Allanasons	Pomfrets, Seer Fish, Squids, Prawns, and Cuttle Fish
ASF Seafoods	ASF Seafoods	Seafood
Bell Foods marine division	Bell Foods	Crab, Cuttlefish, Shrimps, Squid, Fish, Octopus
Deep Sea Products	Deep Sea Products	Marine Products

Gadre Marine Exports	Gadre Marine	Fish Products, Surimi Crab Claws, Crab Sticks, Shrimps, Surimi Crab Patti, Marine Products, Lobsters
IFB Agro Pvt. Ltd.	IFB	Pomfrets, crabs, Prawns, and Sea Food
Sea Sparkle	OKK Fresh	Octopus, Squid, Crabs and Tuna
OKK Fresh	Sea Sparkles	Promfrets, Crabs, Praws and Octopus
Sumero	Sumero	Pomfrets, Crabs, Prawns and Sea Food

Source: Technopak Analysis

As discussed earlier, around 95% of the seafood processing units in the country are concentrated in the 20 major clusters in twelve maritime States where fish catche is the highest. We visited Cochin cluster and visited seven industries for the collection of the primary data. Brief over view of the Cochin Cluster is provided below:

Cochin Cluster: Seafood business is one of the front line businesses in Cochin. Total approximately 45-50 seafood processing units exist in Cochin and most of those units are exporting. August, September and October are considered to be the best season for seafood exports. Maximum units are functioning since last 10 to 12 yr. Majority of the units operatein 2 shifts. The equipments in this industry are Freezers-capacity (30T), Air blast freezers-capacity (30 MT), Water treatment plant, Pre-processing plant, Flake ice machines - ice production (40 MT/day), Cold storage capacity 360 MT to 700 MT, Compressor (110 hp, 75 hp, 50 hp, 25 hp), D.G. Sets (125 /150 / 165 kva), Motor (up to 120 hp), etc. The major energy consuming equipment is compressor /freezers. The energy cost is approximately 5% of the total production cost wherein the raw material cost is around 70%. The entire process is semi mechanized & is seasonal in nature. Nearly 21500 tonnes of raw fish is consumed by 24 units.

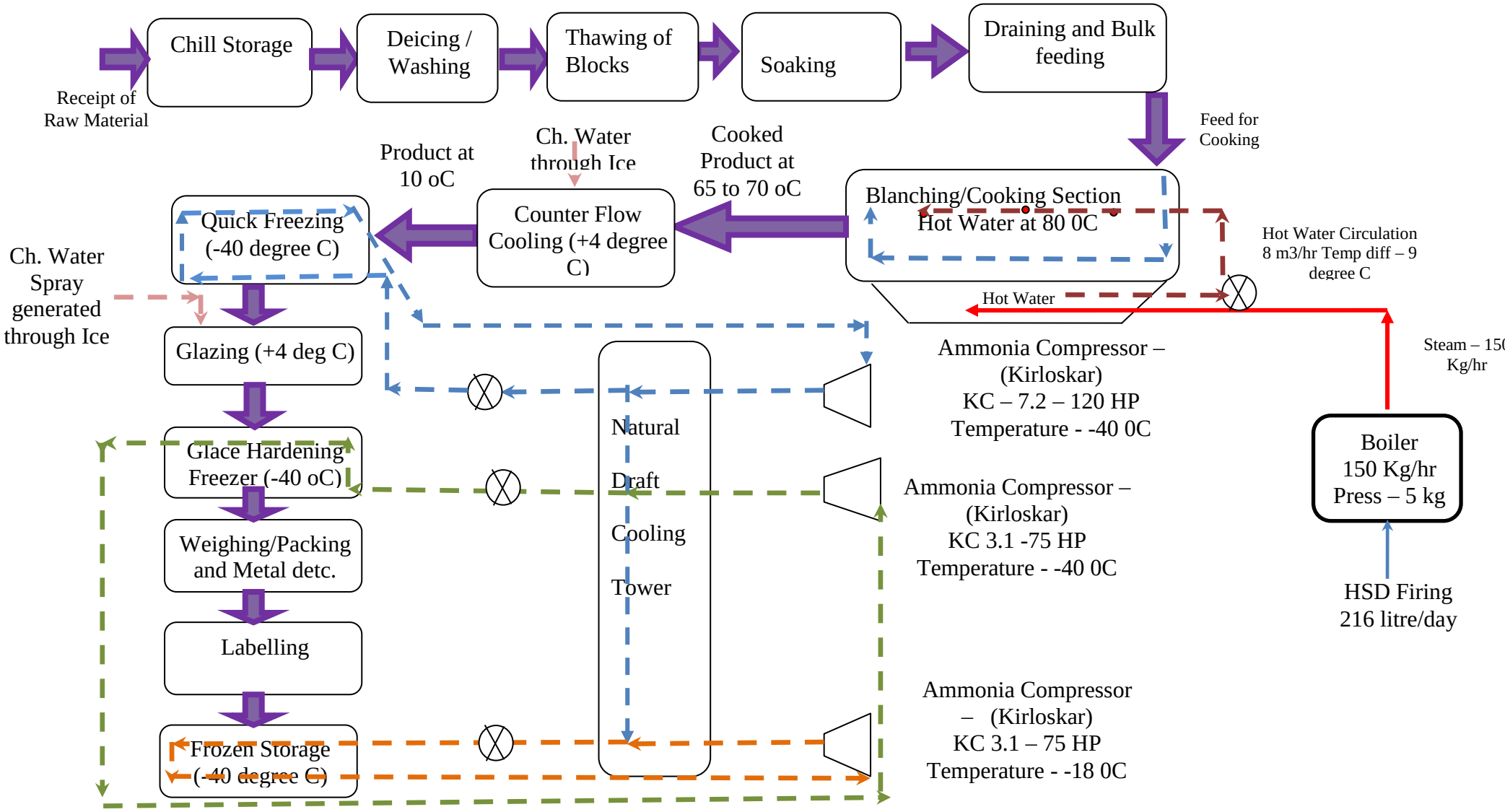
5.5.2 Seafood Process and Integration of SWHS

Processing of the Seafood involves various steps such as receipt of the raw material, chilled storage/frozen storage, deicing and washing, thawing of blocks, soaking, draining and bulk feeding, cooking, counter flow cooling, quick freezing, glazing, glace hardening, weighing and packing, metal detection, storage and distribution etc. Seafood processing industry provides opportunities for the installation of SWH systems for both direct as well as indirect applications. Typical process flow diagram of a seafood processing industry is shown in figure 6.8 on the next page.

Steam is generated using HSD / LPG fired boiler to meet the heating requirement of the processing unit. Steam is mainly utilised for the generation of hot water, which is required in

the cooking section. Hot water of around 80°C is required for cooking of the blocks. Condensate is recovered and sent back to the boiler feed water tank. Requirement of the makeup water depends on the percentage of the condensate recovered. It is possible to install SWH to generate hot water for the process applications and make up water requirement.

Seafood processing industry has also installed various types of chilling units in order to maintain different temperatures in the area of Chill storage, frozen storage and quick freezer. Temperatures of around +4°C, - 40°C and -20°C are required in different sections of the processing industry.


Receipt of Raw Material
Chill Storage
Deicing / Washing
Thawing of Blocks
Soaking
Draining and Bulk feeding
Feed for Cooking
Blanching/Cooking Section
Hot Water at 80 0C
Cooked Product at 65 to 70 oC
Counter Flow Cooling (+4 degree C)
Ch. Water through Ice
Product at 10 oC
Quick Freezing (-40 degree C)
Ch. Water Spray generated through Ice
Glazing (+4 deg C)
Glace Hardening Freezer (-40 oC)
Weighing/Packing and Metal detc.
Labelling
Frozen Storage (-40 degree C)
Natural Draft Cooling Tower
Hot Water Circulation 8 m3/hr Temp diff – 9 degree C
Hot Water
Steam – 150 Kg/hr
Boiler 150 Kg/hr Press – 5 kg
HSD Firing 216 litre/day
Ammonia Compressor – (Kirloskar) KC – 7.2 – 120 HP Temperature - -40 0C
Ammonia Compressor – (Kirloskar) KC 3.1 -75 HP Temperature - -40 0C
Ammonia Compressor – (Kirloskar) KC 3.1 – 75 HP Temperature - -18 0C

5.5.3 Realisable SWH Potential in Seafood Processing Industry

Seafood Processing Industry has potential for both direct as well as indirect heating applications. It is difficult to implement and integrate SWH systems for the indirect heating application in the seafood processing industries. We visited more than ten seafood processing industries located in Kochi cluster in the State of Kerala for primary data collection purpose. Out of ten seafood industries, only three industries were utilising hot water at 80°C in the Cooking section for cooking of the fish prior to sending the same for frozen storage, whereas other industries were not doing cooking of the fish. Based on the collected information, we have assessed the maximum realisable SWH potential in the abovementioned seafood industries considering various constraints. We have also collected data related to different forms of energy utilised in the seafood processing industries. Primary data collected from three sea food processing industries and their fuel consumption is provided in the table 5.8 & 5.9 respectively.

Table5.8: Hot water requirement in Sea Food Processing Industry and Land availability

Industry Name			Koluthara Exports	Mangala Marine Exim	Accelerated Freeze	Overall Parameters
Co-Generation Status			No	No	No	
Industry No			1	1	1	3
Solar Potential For Boiler Feed Water Heating	Temp (0C)	Required	80	80	80	80
		Possible	80	80	80	80
	Hot Water Quantity (LPD)		2700	4000	30000	36700
Solar Potential For Process Heating (Direct Hot water Application)	Temp (0C)	Required	80		80	80 - 110
		Possible	80		80	80
	Hot Water Quantity (LPD)		8000		78500	86500
Overall Swh Potential For Industries Surveyed			10700	4000	108500	123200
Estimated Land Requirement for SWH Installtion (Acres)			0.08	0.03	0.86	0.97
Land Available for SWH installation			0.1	0.1	0.4	0.6
Maximum Implementable SWH Potential After considering Space Constraint	SWH Capacity (LPD)		10700	4000	50613.2	65313.2
	% of Total Potential		100.0%	100.0%	46.6%	53.01%

Source: ABPS Infra Research & Analysis

Table5.9 : Different Types of Fuel Used in Sea Food Processing Industries

Industry Name		Koluthara Exports		Mangala Marine Exim		Accelerated Freeze		Overall Parameters	
Energy Utilised From Different energy Sources (Million kCal)	Energy Source	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total
	Electricity	774	53.9%	1135	48.1%	4128	36.0%	6,037	39.5%
	Indian Coal							-	0.0%
	Imported Coal							-	0.0%
	FO							-	0.0%
	Bagasse							-	0.0%
	Wood							-	0.0%
	Briquette/Rice Husk							-	0.0%
	LPG							-	0.0%
	LDO/HSD	661	46.1%	1224	51.9%	7344	64.0%	9,229	60.5%
	Solar							-	
	Total	1435	100%	2359	100%	11472	100%	15,266	100%

Source: ABPS Infra Research & Analysis

Analysis of the table shows that most of all seafood processing industries utilise electricity and HSD/LDO to meet their thermal as well as electrical energy requirement. Data provided in table 5.8 & 5.9 is analyzed to generate different projection scenarios (realistic, optimistic and pessimist) for both direct hot water applications as well as indirect hot water applications. We have also assumed 3% growth rate for increase in the number of seafood processing industries and estimated maximum possible SWH penetration over the next twelve years under the realistic scenario and the same is presented in table 5.10 below:

Sea Food Processing Industry- SWH Potential Scenario		Realistic
Number of Sea Food Processing Units in India in Base Year FY 10	No.	399
Average Hot water Requirement per day for Direct application For Sea Food Processing Industry	LPD	41067
Overall Hot Water Requirement for Direct Applications in Sea Food Processing Industry	LPD	16385600
Increase in number of sea food processing industry during 2011-2022	%	3.00%

SWH Scenario For Sea Food Processing Industry			1	3	5	7	9	11	12
			FY11	FY13	FY15	FY17	FY19	FY21	FY22
All India Number of Installed Sea Food Processing Industry	Year On Year	No	411	436	463	491	521	552	569
All India Hot water requirement in Sea Food Processing	Year On Year	LPD	16877168	17904988	18995401	20152221	21379491	22681503	23361948
All India Hot Water Requirement considering space constraints	Year On Year	LPD	16877579	17905424	18995864	20152712	21380012	22682055	23362516
Year Wise % SWH penetration in Realistic Scenario	Year On Year	%	2.64%	2.64%	2.64%	2.64%	2.64%	2.64%	2.64%
	Cumulative	%	2.64%	7.92%	13.20%	18.48%	23.76%	29.04%	31.68%
Maximum Achievable SWH Penetration in Realistic Scenario	Year On Year	LPD	236173	250556	265815	282003	299177	317397	326919
	Cumulative	LPD	236173	729989	1253877	1809670	2399311	3024862	3351781
		M2	5743	17751	30491	44006	58345	73556	81506

Source: ABPS Infra Research and Analysis

Estimation of overall realisable SWH potential for Seafood Processing Industries has also been carried out in terms of LPD and Square Meter of the collector area for the next twelve years under three different scenarios and the same is presented in Table 5.11 below:

Table5.11: SWH Potential Scenarios in Seafood Processing Industries

		FY13	FY17	FY22
Realistic Scenario	LPD	729989	1809670	3351781
	M^2	17751	44006	81506
Optimistic Scenario	LPD	898447	2227286	4125269
	M^2	21848	54161	100315
Pessimistic Scenario	LPD	561530	1392054	2578293
	M^2	13655	33851	62697

Cumulative overall realisable SWH potential for the Seafood Processing Industries under realistic scenario will be around 81506 Square Meter in the year FY 2022. State wise realisable SWH potential in the Seafood Processing Industry is provided in overall Industrial SWH potential section.

5.6 Beer Industry

Drinking practice vary substantially among different countries and different masses. But alcoholic beverages are very popular among all ages of people. The alcoholic drink market is broadly classified in to five classes, starting with beers, wine, hard liquors, liqueurs and others. The Indian alcoholic market has been growing rapidly for the last ten years, due to the positive impact of demographic trends, expected changes like rising income level, changing age profile, changing life style and reduction in beverages prices. Beer and Wine are perhaps the oldest and most popular of all alcoholic beverages in the world.

5.6.1 Overview of Indian Beer Industry

The Indian Beer Industry has been witnessing a steady growth rate of 7-9% per year for the last ten years. Apart from Kingfisher and Foster Beer, the other brands in Indian markets are Carling Black Label, Carlsberg, Dansberg, Golden Eagel, Haywards 5000, Premium Large, Kingfisher Strong, etc. to name a few.

India presents a huge growth potential for alcoholic beverages sales. The domestic production of beer is on the rise with official statistics reporting a 12% increase in domestic production. Increasing GDP, favourable growth in demographics with a growing urban middle class, growth of modern retail formats, rationalisation of taxation rules, and ban on local country liquor, rising health consciousness and age preference act in favour of growth of beer industry in India in near future.

Beer is popular beverages all over the world and contains alcohol ranges from 8 to 9%. It is found effective in improving appetite and is considered good for health. Formulations of beer manufacturing are done with availability of raw materials in that particular part where the brewery is established. Beer Units are concentrated in the States of Maharashtra, Karnataka, Uttar Pradesh and Goa with no units in Assam, Tripura, Tamilnadu, Gujarat, Orissa, Rajasthan and Bihar. Ten major beer manufacturers in the organised sector having the combined market share of about 75 percent are United Breweries, Mohan Breweries and Distilleries, Skol Breweries, Mohan Meakin, Mysore Breweries, Charminar Breweries, Aurangabad Breweries, Hindustan Breweries and Mount Shivalik Breweries.

Like distilled spirits, beer is classified as socially not preferred luxury in India. The excise and sales taxes are as high as 80% exclusive of retail fees, license fees and other levies. Additional import duties for beer are levied as per respective state policies. Despite liberalization and foreign direct investment (FDI) approvals in the beer sector, it is still heavily licensed. Bureaucracy and political patronage play a key role in the setting up of greenfield breweries. Deregulation in licensing and a reduction in taxes would open up the beer market. Enhancement of capacity is less bureaucratic and less time consuming than building large breweries. Realizing the importance of FDI, some states have reduced excise taxes. For instance, Goa has introduced the system of retailing beer through regular grocery stores for an annual license fee of Rs 15,000 (USD 340).

5.6.2 Beer Manufacturing Process and Integration of SWHS

Brewing is the production of beer through steeping a starch source (commonly cereal grains) in water and then fermenting with yeast. The basic ingredients of beer are water; a starch source, such as maltedbarley, which is able to be fermented (converted into alcohol); a brewer's yeast to produce the fermentation; and a flavouringsubstancesuch as hops. A secondary starch source (an adjunct) may be used, such as maize (corn), rice or sugar. Less widely used starch sources include millet, sorghum and cassava root in Africa, potato in Brazil, and agave in Mexico, among others. The amount of starch in a beer recipe is collectively called the grain bill.

There are several steps in the brewing process, which include malting, milling, mashing, lautering, boiling, fermenting, conditioning, filtering, and packaging. There are three main fermentation methods, warm, cool and wild or spontaneous. Fermentation may take place in open or closed vessels. There may be a secondary fermentation, which can take place in the brewery, in the cask or in the bottle.

All beers are brewed using a process based on a simple formula. Key to the process is maltedgrain— mainly barley, though other cereals, such as wheat or rice, may be added. Malt is made by allowing a grain to germinate, after which it is dried in a kiln and sometimes roasted. The germination process creates a number of enzymes, notably α-amylase and β-amylase, which convert the starch in the grain into sugar. Depending on the amount of roasting, the malt will take on a dark colour and strongly influence the colour and flavour of the beer. The malt is crushed to break apart the grain kernels, expose the cotyledon, which contains the majority of the carbohydrates and sugars, increase their surface area, and separate the smaller pieces from the husks.There are several steps in the brewing process, which include malting, milling, mashing, lautering, boiling, fermenting, conditioning, filtering, and packaging.

Malting is the process where the barley grain is made ready for brewing. Malting is broken down into three steps, which help to release the starches in the barley. First, during steeping, the grain is added to a vat with water and allowed to soak for approximately 40 hours. During germination, the grain is spread out on the floor of the germination room for around 5 days. The goal of germination is to allow the starches in the barley grain to breakdown into shorter lengths. When this step is complete, the grain is referred to as green malt. The final part of malting is kilning. Here, the green malt goes through a very high temperature drying in a kiln.

The temperature change is gradual so as not to disturb or damage the enzymes in the grain. When kilning is complete, there is a finished malt as a product.

The next step in the brewing process is milling. This is when the grains that are going to be used in a batch of beer are cracked. Milling the grains makes it easier for them to absorb the water that they are mixed with and which extracts sugars from the malt. Milling can also influence the general characteristics of a beer.

Mashing is the next step in the process. This process converts the starches released during the malting stage, into sugars that can be fermented. The milled grain is dropped into hot water in a large vessel known as a mash tun. In this vessel, the grain and water are mixed together to create a cereal mash. The leftover sugar rich water is then strained through the bottom of the mash in a process known as lautering. Prior to lautering, the mash temperature may be raised to about 75 °C (165-170 °F) (known as a mashout) to deactivate enzymes. Additional water may be sprinkled on the grains to extract additional sugars (a process known as sparging).

At this point the liquid is known as wort. The wort is moved into a large tank known as a "copper" or kettle where it is boiled with hops and sometimes other ingredients such as herbs or sugars. This stage is where many chemical and technical reactions take place, and where important decisions about the flavour, colour, and aroma of the beer are made. The boiling process serves to terminate enzymatic processes, precipitate proteins, isomerize hop resins, and concentrate and sterilize the wort. Hops add flavour, aroma and bitterness to the beer. At the end of the boil, the hopped wort settles to clarify in a vessel called a "whirlpool", where the more solid particles in the wort are separated out.

After the whirlpool, the wort then begins the process of cooling. This is when the wort is transferred rapidly from the whirlpool or brew kettle to a heat exchanger to be cooled. The heat exchanger consists of tubing inside a tub of cold water. It is very important to quickly cool the wort to a level where yeast can be added safely. Yeast is unable to grow in high temperatures.

After the wort goes through the heat exchanger, the cooled wort goes into a fermentation tank. A type of yeast is selected and added, or "pitched", to the fermentation tank. When the yeast is added to the wort, the fermenting process begins, where the sugars turn into alcohol, carbon dioxide and other components.

The last but one stage in the brewing process is called racking. This is when the brewer racks the beer into a new tank, called a conditioning tank. Conditioning of the beer is the process in which the beer ages, the flavour becomes smoother, and unwanted flavours dissipate.

After one to three weeks, the fresh (or "green") beer is run off into conditioning tanks. After conditioning for a week to several months, the beer enters the finishing stage. Here, beers that require filtration are filtered, and given their natural polish and colour. Filtration also helps to stabilize the flavour of the beer. After the beer is filtered, it undergoes carbonation, and is then moved to a holding tank until bottling. Hot water at around 60 to 70 degree C is required in brewing process in meshing section. Hot water is produced by firing the fuel in the boiler.

5.6.3 Realisable SWH Potential in Beer Manufacturing Industry

Beer Manufacturing Industry has mainly direct SWH applications. As direct application, SWH can be used for boiler makeup water heating as well as in brewing section. For the market assessment study purpose, we selected and visited five beer manufacturing industries located in the Aurangabad Cluster in Maharashtra State. Based on the collected information, we have estimated land requirement for the installation of SWHS to realise the overall potential. Availability of the land in each industry was also collected during the market assessment survey of that particular industry. Based on the same, maximum implementable SWH potential is assessed for the five industries. Information collected from beer manufacturing industries through market assessment survey is provided below in Table 5.12 below:

Table 5.12: Hot water requirement in Beer Industry and Land availability

Industry Name			Asia Pacific Brew.	Carlsberg India	Lailasong Ind	Millenium Beer Ind.	SAB Miller	Overall Parameters
Co-Generation Status			No	No	No	No	No	
Production in KL/Annum			27300	25000	12100	60840	21840	147080
Solar Potential For Boiler Feed Water Heating	Temp (0C)	Required	80	80	80	80	80	80
		Possible	80	80	80	80	80	80
	Hot Water Quantity (LPD)		400000	100000	60000	840000	120000	1520000
Solar Potential For Process Heating (Direct Hot water Application)	Temp (0C)	Required	80	80	80	80	80	80 - 110
		Possible	80	80	80	80	80	80
	Hot Water Quantity (LPD)		20000	10000	10000	25000	40000	105000
Overall Swh Potential For Industries Surveyed			420000	110000	70000	865000	160000	1625000
Estimated Land Requirement for SWH Installtion (Acres)			3.32	0.87	0.55	6.84	1.26	12.84
Land Available for SWH installation			1.5	0.3	0.23	3	0.5	5.53
Maximum Implementable SWH Potential	SWH Capacity (LPD)		189800	37960	29103	379599	63267	699727
After considering Space Constraint	% of Total Potential		45.2%	34.5%	41.6%	43.9%	39.5%	43.06%

Source: ABPS Infra Research & Analysis

Majority of the beer manufacturing industries utilise coal and furnace oil as a fuel to fulfil their thermal energy requirement. However, they also draw electricity from the distribution company for the various applications. We collected information about different types of fuels used in abovementioned five industries and the same is presented in Table 7.13 below:

Table 5.13: Different Types of Fuels Used in Beer Industry

Industry Name		Asia Pacific Brew.		Carlsberg India		Lailasong Ind		Millenium Beer Ind.		SAB Miller		Overall Parameters	
Energy Utilised From Different energy Sources (Million kCal)	Energy Source	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total
	Electricity	32,852	77.0%	3096	17.0%	2322	11.2%	5590	15.6%	2476.8	20.8%	46,337	35.8%
	Indian Coal			15120	83.0%	18480	88.8%					33,600	26.0%
	Imported Coal											-	0.0%
	FO	9,800	23%							9408.0	79.2%	19,208	14.8%
	Bagasse											-	0.0%
	Wood											-	0.0%
	Briquette/Rice Husk							30240	84.4%			30,240	23.4%
	LPG											-	0.0%
	LDO/HSD											-	0.0%
	Solar											-	0.0%
	Total	42652	100%	18216	100%	20802	100%	35830	100%	11885	100%	129,385	100%

Source: ABPS Infra Research & Analysis

We have analysed the data presented in Table 5.12 & 5.13 to develop various scenarios (realistic, optimistic and pessimist) for the major hot water application. Based on the same, we have estimated maximum possible SWH penetration mainly for the direct application over the next twelve years under realistic scenario and the same is provided in table 7.14 below:

Beer Industry - SWH Potential Scenario		Realistic
Beer Production in India in the year 2009-10	KL	1112000
Average Hot water Requirement per day for Direct application For Beer Industry	LPD	11
Overall Hot Water Requirement for Direct Applications in Beer Industry	LPD	12285831
Growth Rate of Beer Industry during 2011 to 2022 (India Stat)	%	9.80%

SWH Scenario For Beer Industry			1	3	5	7	9	11	12
			FY11	FY13	FY15	FY17	FY 19	FY21	FY22
ALL India Beer Production in KL	Year On Year	No	1220976	1472014	1774665	2139544	2579442	3109786	3414545
All India Hot water requirement in Beer Industry	Year On Year	LPD	13489842	16263408	19607229	23638554	28498736	34358190	37725292
All India Hot Water Requirement considering space	Year On Year	LPD	5808747	7003048	8442903	10178798	12271599	14794689	16244569
Year Wise % SWH penetration in Realistic Scenario	Year On Year	%	1.74%	1.74%	1.74%	1.74%	1.74%	1.74%	1.74%
	Cumulative	%	1.74%	5.22%	8.70%	12.19%	15.67%	19.15%	20.89%
Maximum Achievable SWH Penetration in Realistic Scenario	Year On Year	LPD	101130	121923	146990	177212	213648	257575	282817
	Cumulative	LPD	101130	334093	614955	953563	1361790	1853950	2136767
		M2	2459	8124	14954	23188	33115	45083	51960

Source: ABPS Infra Research & Analysis

We have also estimated overall realisable SWH potential for Beer Manufacturing Industry in terms of LPD & Square Meter of the collector area required for next twelve years under realistic, optimistic and pessimistic scenarios and the same is presented in Table 5.15 below:

Table 5.15: SWH Potential Scenarios in Beer Industry

		FY13	FY17	FY22
Realistic Scenario	LPD	334093	953563	2136767
	M^2	8124	23188	51960
Optimistic Scenario	LPD	411192	1173616	2629866
	M^2	9999	28539	63951
Pessimistic Scenario	LPD	256995	733510	1643667
	M^2	6249	17837	39969

From the above table, it can be seen that cumulative overall realisable SWH market potential will be 51960 square meter of the collector area in the FY 2022 under the realistic scenario (most likely). Southern and Western Region States will contribute maximum 49% and 37% respectively in achieving realisable SWH potential out of total SWH realisable SWH potential.

5.7 Sugar Industry

5.7.1 Overview of Indian Sugar Industry

Brazil, India, China and USA are major sugar producing countries accounting for 45% of the total sugar production in the world. The world sugar production has been increasing steadily at a CAGR of 1.5%. Currently the total world sugar production stands at 150 million Tons (MT) of sugar. Brazil is the largest producer of sugar and its production has increased at a CAGR of 5.7% over the last seven-years. Brazil's growth as a sugar producer has been driven by an increased acreage supported by the conducive regulatory environment and a strong focus on

ethanol. Brazil expects to increase its sugar production to 125 MT by 2013 and thereby increase its share of exports in the world trade. However, the world sugar balance forecast for the period from October 2009 to September 2010 shows a widening gap between world consumption and global output.India is now the largest consumer of sugar in the world. Although subject to cyclical fluctuations, sugar production has grown phenomenally during the last decade.

It expanded from 16.44 million tonne in FY 1995-96 to 18.5 million tonne in FY 2000-01, representing an annual growth of just 2.4% during the period. In the interregnum, the production had slumped to 12.8 million tonne in FY 1997-98. The production after remaining static the very next year, jumped to over 20 million tonne in FY 2002-03. The years following witnessed drop in production to 13.5 million and 12.7 million tonne in FY 2003-04 and FY 2004-05, respectively, a fall of nearly 20.5% a year between FY 2002-03 and FY 2004-05. India continued to have a comfortable demand-supply position throughout the 2000s so far, except for 2004-05, when the country had to resort to imports of over 2 million tonne.

The next two years, ending FY 2006-07, however, witnessed a sharp increase to 19.3 million tonne and 28.3 million tonne, respectively. In fact, the increase in FY 2006-07 was a stupendous 46.9%. This was also the result of a 15% increase in the installed capacity during the year. The production in sugar year FY 2007-08 at 26.3 million tonne saw a decline of 7%. With the consumption in FY 2007-08 pegged at 22.5 million tonne and exports at 4.5 million tonne, the industry was left with stocks of 8.5 million tonne by end September 2008. The drop in production and increased consumption put pressure on sugar prices.

India's raw sugar imports are set to touch an all time high of 2.5 million tonne in the sugar season ending September 2009 at high prices (USD 325 to 340 a tonne). This follows a 44% drop in domestic sugar output to 14.7 million tonne. India resumed raw sugar imports after a three-year gap following the drop in domestic production. In the FY 2004-05 season, the country imported 2.13 million tonne raw sugar.

The annual variations in sugar production are a result of alternate sweeteners Jaggery and Khandsari claiming more of sugarcane in times of fall in crop. With passage of time, sugar industry has been liberated from 100% procurement of sugar by government. The existing level of procurement is only 10% of the production.

5.7.2 Sugar Production in India

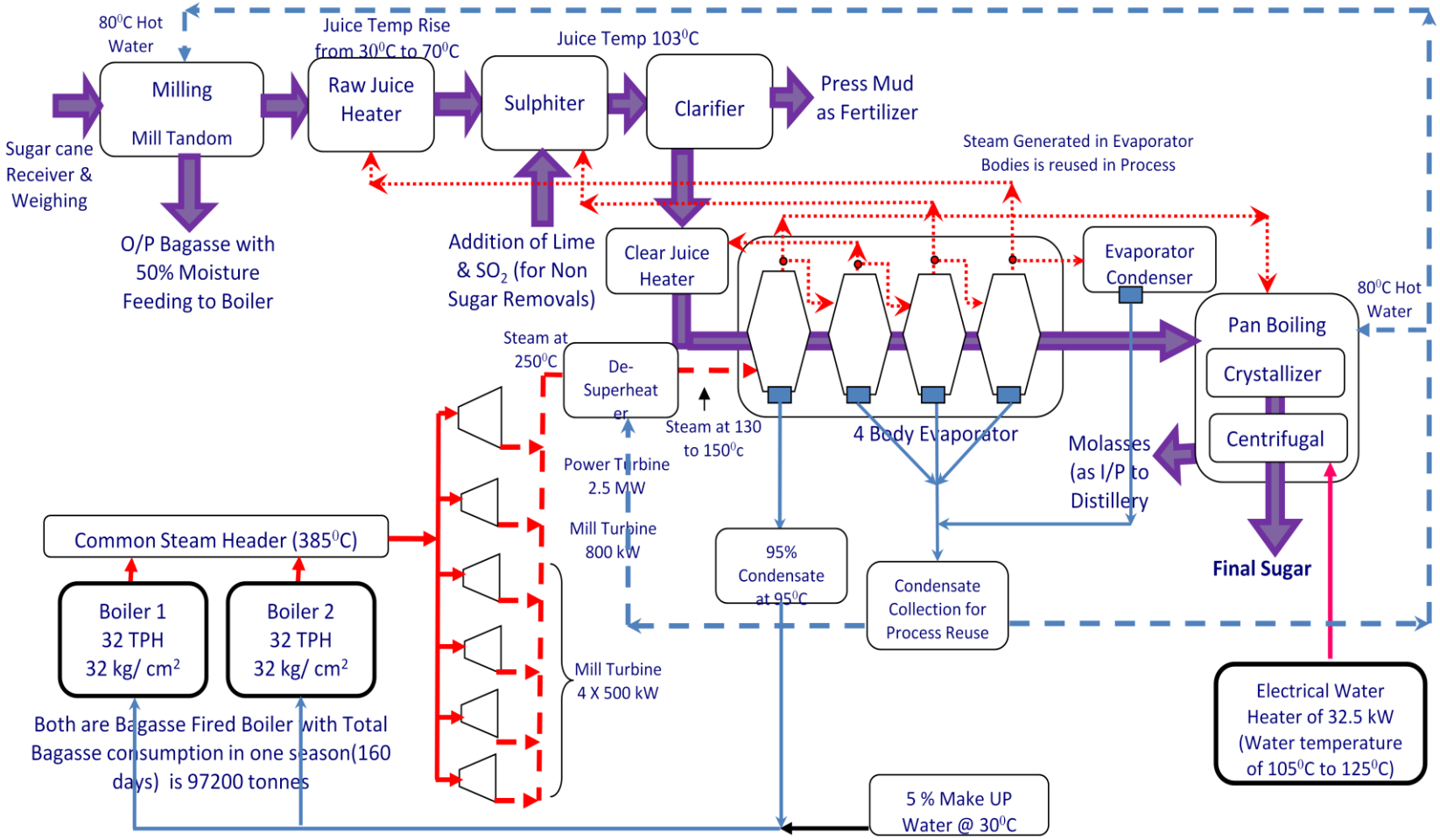
Sugarcane is the primary raw material for sugar production and adequate sugarcane availability is a prerequisite for mill viability. According to Indian Sugar Mill Association (ISMA), production of sugar in 2008-09 was 14.7 mntonne against previous year production of 26.3 mntonne. Sugar production is likely to grow at CAGR of 3.6% during the year of 2011-12 to 2019-20. In India, sugarcane is primarily grown in the States like Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Maharashtra, Punjab, Uttar Pradesh and Tamil Nadu.

5.7.3 Sugar Industry Process and Integration of SWH System

The sugar production process comprised of juice extraction from the sugarcane, juice clarification, and evaporation, crystallization, centrifuging, drying, and packing. The juice extraction plant consists of cane handling, cane preparation and milling sections. The sugarcane after delivery to the cane carrier is levelled in the leveller before it is fed to the cutter. The cutter shreds the cane into smaller sizes. The prepared cane is passed through a milling tandem composed of four to six three-roller mills. The juice is extracted from the cane by squeezing under high pressure in these rollers. The fibrous matter or 'bagasse', which is left after milling is used as a fuel for steam generation (used for evaporation and drying). Typical process flow sheet of a sugar production is shown in Figure 6.11. The quantity of bagasse produced is dependent upon various factors like fibre content in the cane, quantity of juice, type of clarification process and evaporation effects, type of prime movers (steam driven or electric driven) etc. Most sugar mills produce surplus bagasse.

The purification of juice involves (a) juice heating (b) sulphitation (c) clarification and (d) filtration. The mixed juice from the mills is heated in raw juice heater(s). The common process employed in most of the mills in India is Double Sulphitation process. The sugar industry process flow is shown in Figure 7.8.

Figure5.8: Process & Energy Flow in Sugar Industry



As indicated in Figure 5.8, juice is concentrated using multiple-effect evaporator, which is major steam consuming section of the plant. However multiple effect evaporator generates a lot of hot water (condensate) in process. Also, the bagasse is a by-product, which is also available in surplus and is used for steam generation. Considering the fact that in sugar industry there is excessive hot water generated in the process, there is no scope for integration of SWH.

In sugar industry, crystallization is another important operation. Major part of the crystallization process is done in most sugar plants in batch type vacuum pans. A mixture of the molten liquid and crystals, known as 'massecuite', is then transferred to crystallizers where the process is completed by cooling the mass under stirred condition. The massecuite from the vacuum pans is sent to the centrifuges, where the sugar crystals are separated from molasses. The moist crystals obtained from centrifugal machines normally contain about 15-20% surface moisture. They are dried in traditional dryers, graded according to crystal sizes and then packed in bags.

6 SWH POTENTIAL IN RICE MILL

Although the growth rate of India's agricultural sector, in general, and food grains output, in particular, has been modest in recent years, rice has performed relatively better with output growth varying between 1.7 and 3.3 per cent in the last three years. Rice milling is the oldest and the largest agro processing industry of the country. As per Department of Agricultural and Cooperation, India's rice production in 2008-09 was a record 99.18 million tonnes, up from 96.7 million tonnes the previous year and beating the Planning Commissions 11th Plan projections.[5]

6.1 Overview of Rice Mill Industry in India

The Small Industries Development Organisation (SIDO) of Ministry of SSI, Government of India is the key agency responsible for planning, coordinating, monitoring and development of Rice Mills in the country. The Government of India has announced various schemes & policies providing direct & indirect assistance for promotion of this sector.

At present Rice Mill Industry has a turnover of more than Rs 25,500 crore per annum. It processes about 85 million tonnes of paddy per year and provides staple food grain and other valuable products required by over 60% of the population. Paddy grain is milled either in raw condition or after par-boiling, mostly by single hullers of which over 82,000 are registered in the country. Apart from it there are also a large number of unregistered single hulling units in the country. A good number (60%) of these are also linked with par-boiling units and sun-drying yards. Most of the tiny hullers of about 250-300 kg/hr capacities are employed for custom milling of paddy. Apart from it double hulling units (2,600 Units), under run disc shellers cum cone polishers (5,000 units) and rubber roll shellers cum friction polishers (10,000 units) are also present in the country. Further over the years there has been a steady growth of improved rice mills in the country. Most of these have capacities ranging from 2 tonnes /hr to 10 tonnes/ hr.

Department of Agricultural and Cooperation estimated India's rice production of around 99.18 million tonnes in the year 2008-09. Four States namely West Bengal, Uttar Pradesh, Punjab and Andhra Pradesh contributed more than 60% of total rice production in the country. Average Rice yield in the country was around 2158 kg/Hectare in the year 2008-09. Rice yields in the six states such as Maharashtra, Madhya Pradesh, Assam, Bihar, Orissa and Chhattisgarh were less

[5] http://www.thehindubusinessline.com/2009/06/08/stories/2009060850361300.htm

than the national average value of 2158 kg/Hectare in the year 2008-09. It is another matter that India's average yield is far below than that of China, where it is about 3.5 tonnes a hectare. Sustained efforts to raise the yields in the six States to the national average would result in additional output of about 15 million tonnes a year. Area, production of rice and its yield during FY 2007-08 and FY 2008-09 in major States of India are provided below:

Table 6.1: Major Rice Producing States of India

Area - Million Hectares
Production - Million Tonnes
Yield - Kg./Hectare

	2007-08			2008-09		
State	**Area**	**Production**	**Yield**	**Area**	**Production**	**Yield**
West Bengal	5.72	14.72	2573	5.94	15.04	2533
Andhra Pradesh	3.98	13.32	3344	4.39	14.24	3246
Uttar Pradesh	5.71	11.78	2063	6.03	13.10	2171
Punjab	2.61	10.49	4019	2.74	11.00	4022
Orissa	4.45	7.54	1694	4.45	6.81	1529
Bihar	3.57	4.42	1237	3.50	5.59	1599
Tamil Nadu	1.79	5.04	2817	1.93	5.18	2683
Chattisgarh	3.75	5.43	1446	3.73	4.39	1176
Assam	2.32	3.32	1428	2.48	4.01	1614
Karnataka	1.42	3.72	2625	1.51	3.80	2511
Jharkhand	1.65	3.34	2018	1.68	3.42	2031
Haryana	1.08	3.61	3361	1.21	3.30	2726
Maharashtra	1.57	3.00	1903	1.52	2.28	1501
Madhya Pradesh	1.56	1.46	938	1.68	1.56	927
Gujarat	0.76	1.47	1942	0.75	1.30	1744
Kerala	0.23	0.53	2310	0.23	0.59	2519
Others	1.74	3.50	@	1.75	3.56	@
All India	**43.91**	**96.69**	**2202**	**45.54**	**99.18**	**2178**

Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation.

In order to further develop this sector in a planned & effective matter, the SIDO, Government of India has come up with an innovative project of CLUSTER DEVELOPMENT PROGRAMME. This is a time bound project and aims to systematically develop & upgrade cluster of Industries as a whole with the involvement of Government, supporting institutions & the industry. Out of

358 clusters identified in the country, the cluster development programme has been initially taken up for at least one cluster group from every state. Brief overview of two clusters is provided below:

Vellore Cluster (Tamil Nadu):A total of more than 150 units in all categories are spread across the two clusters of Arni&Arcot in Vellore. There are approximately very few rice mills in Vellore town. Majority of the units are spread across Arcot, which is 2.5 kms from Vellore. Majority of the mills are modern. Besides this the other location where majority of the mills are spread is Arni. The clusters are clearly demarcated by the type of mills – modern rice mills which fetch Rs. 600 - Rs. 900 per bag of 75 kg and the other one Arcot which caters mainly to the Split rice - cattle feed.

The characteristics of the units are different in terms of end product. In Arni, modern technology is being used wherein they use colour sorter as well as whitener to polish the rice which fetches them a premium and high value compared to Arcot. The units are all in operation for last 15-20 years except for some units, which have come up in the last one year. All the units are operating for single shift. The major equipments are boiler, dryer, huller, and extractor in case of split rice (black rice), which is manufactured in and across Arcot. And in case of these modern mills, the major equipments are colour sorters and whitener which gives shining and fetches them a higher return. The major fuel is electricity; firewood is mainly used for the boiler. The raw material is steamed paddy. The major issue in this cluster is availability of manpower. All the units consume electricity as a fuel and 45 units use firewood as a fuel. 101040 tonnes per annum of raw paddy is required. 5289400 units of electricity and 11830 tonnes per annum of firewood is consumed in the cluster.

Warangal Cluster: The cluster is spread across Khamam, Nakkalpally Road, Rajupet, IDA Rampur, Gorrekunta. There are approximately 125 small scale units in this cluster wherein boiled rice as well as raw rice is produced. All the units are quite recent, approximately 10-12 years in operation; and certain units are only 2-3 years old.While most units operate in a single shift, some units operate in 2 shifts - 12 hours. The major equipments used are Elevator, Rubber Sheller, and Polisher. The production /operation is seasonal in nature and the peak season is during October to February wherein the production goes up to 6 tpd. The major fuel is electricity, husk, and firewood. The major issue in this cluster is availability of manpower as

well as high raw material price. In this cluster it was observed that a number of units use husk feeder, a microprocessor based unit, which is a vibrating type used for paddy boiling furnace and it saves around 20%.

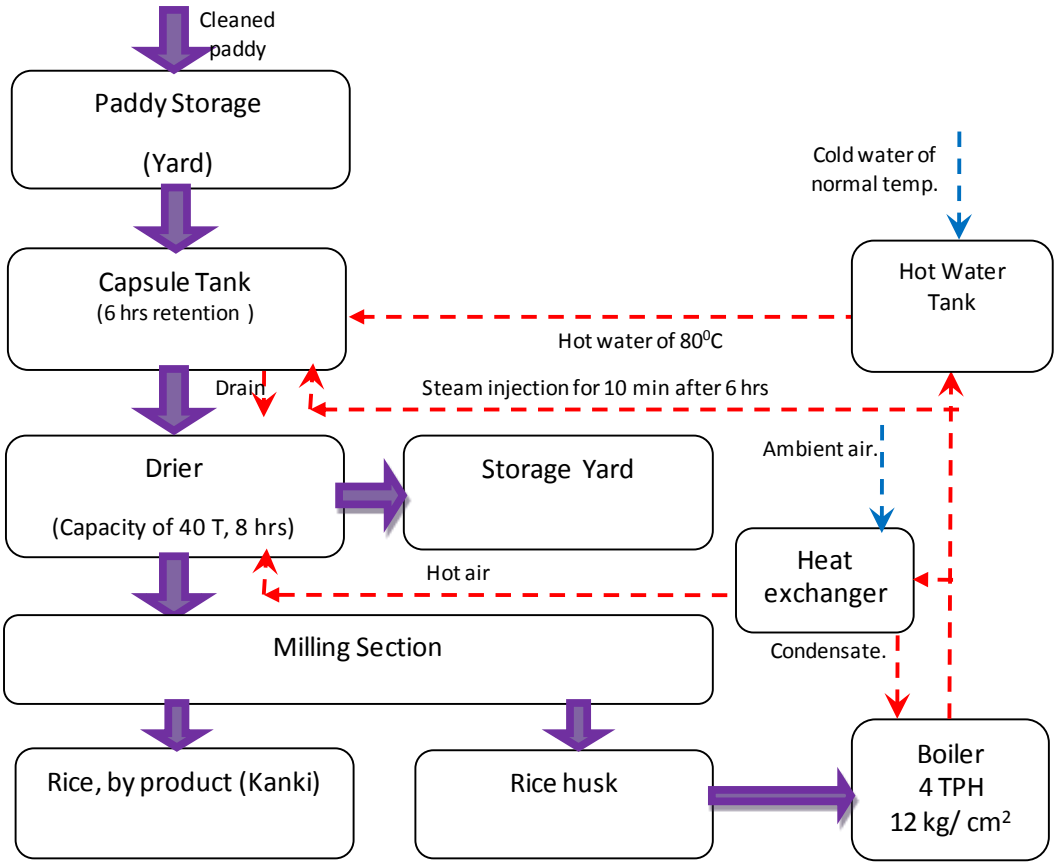
6.2 Rice Mill Industry Process and Integration of SWHS

Paddy in its raw form cannot be consumed by human beings. It needs to be suitably processed for obtaining rice. Rice milling is the process, which helps in removal of hulls and barns from paddy grains to produce polished rice. Rice forms the basic primary processed product obtained from paddy,whichis further processed to obtain secondary and tertiary products.

The basic rice milling processes consist of pre cleaning, de-stoning, parboiling, Husking, Husk Aspiration, Paddy Separation, Whitening, Polishing, Length Grading, Blending and Weighing & Bagging. In rice mill processing, pre-cleaning and de-stoning are the processes to remove all impurities and unfilled grains from paddy and separating small stones from paddy respectively. By parboiling the nutritional quality is improved by gelatinization of starch inside the rice grain. It improves the milling recovery percent during de-shelling and polishing / whitening operation. Parboiling rice mills are the mills where hot water is required for parboiling process. Parboiling is followed by removal of husk from paddy and separation of the husk from brown rice/ un-husked paddy. After these processes, un-husked paddy is separated from brown rice followed by removal of all or part of the barn layer and germ from brown rice (Whitening).

Processes indicating thermal energy requirement and its flow in Rice mill are mapped in Figure 8.1 below. As indicated in Figure 8.1 thermal energy in the form of 80^0C hot water and steam is utilized for parboiling in capsule tank of rice mill.

Figure 6.1 : Process & Energy Flow in Rice Mill Industry



In capsule tank, paddy is cooked for 6 to 8 hrs by means of hot water of around 80⁰C, which is kept on circulating through the paddy. Steam is directly injected to the paddy for around 10 minsfor cooking. Normal water is sprayed to maintain the temperature. This application in parboiling rice mill industry can be clearly replaced by SWH based hot water. Since, hot water is only required during the processing of the parboiled rice, we have considered processing of 30% of total rice production in order to calculate specific hot water requirement per kg of rice mill processing and estimation of realisable SWH potential in the Rice Mill processing Industry.

6.3 Realisable SWH Potential in Rice Mill Industry

Rice Mill industry has only direct SWH applications. As direct application, SWH can be used for boiler makeup water heating as well as for processing in case of parboiled rice mills. In case of raw rice processing mills there is no scope for SWH application. In India parboiled rice forms about 30% of total rice produced. For the purpose of assessment of market, we selected and

visited five rice mills located in the State of Chhattisgarh. Based on the collected information, we have estimated land requirement for the installation of SWHS to realise the overall potential. Availability of the land in each industry was also collected during the market assessment survey of that particular industry. Based on the same, maximum implementable SWH potential after considering the space constraint is assessed for the five industries. Information collected from Rice mills through market assessment survey is provided below in Table 6.2 below:

Table 6.2: Hot water requirement in Rice Mill Industry and Land availability

Industry Name			Bhagawati Industries	Chhattisgarh Rice Mills	P D Rice Udyog	Sanjay Grain Products Private Limited	Satyam Balaji Rice Industries	Overall Parameters
Co-Generation Status			No	No	No	No	No	
Production (tonnes/ Annum)			12550	5600	12550	81600	75000	187300
Solar Potential For Boiler Feed Water Heating	Temp (0C)	Required	80	80	80	80	80	80
		Possible	80	80	80	80	80	80
	Hot Water Quantity (LPD)		21100	12800	21100	25200	24000	104200
Solar Potential For Process Heating (Direct Hot water Application)	Temp (0C)	Required	80	80	80	80		80
		Possible	80	80	80	80		80
	Hot Water Quantity (LPD)		40000	27000	40000	30000	0	137000
Solar Potential For Hot Air Generation	Quantity of HOT Air (m3/hr)		69450	41485	69450	81719		262104
	Temp (0C)	Required	110	110	110	110		110
		Possible	80	80	80	80		80
	Hot Water Quantity (LPD)		439456	157502	439456	517091		1553505
Overall Swh Potential For Industries Surveyed			61100	39800	61100	55200	24000	241200
Estimated Land Requirement for SWH Installtion (Acres)			0.48	0.31	0.48	0.44	0.19	1.91
Land Available for SWH installation			0.5	0.1	0.25	0.1	0.5	1.45
Maximum Implementable SWH Potential After considering Space	SWH Capacity (LPD)		61100	12653	31633	12653	24000	142039.85
	% of Total Potential		100.0%	31.8%	51.8%	22.9%	100.0%	58.89%

Source: ABPS Infra Research & Analysis

Majority of the rice mills utilise rice husk as a fuel to fulfil their thermal energy requirement. However, they also draw electricity from the distribution company for the various applications. We collected information about types of fuels used in these five industries and the same is presented in Table 6.3 below:

Table 6.3: Different Types of Fuels Used in Rice Mill Industry

Industry Name		Bhagawati Industries		Chhattisgarh Rice Mills		P D Rice Udyog		Sanjay Grain Products Private Limited		Satyam Balaji Rice Industries		Overall Parameters	
Energy Utilised From Different energy Sources (Million kCal)	Energy Source	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total
	Electricity	688	4.8%	129	1.2%	688	4.8%	826	1.0%	344	0.4%	2,675	1.2%
	Indian Coal											-	0.0%
	Imported Coal											-	0.0%
	FO											-	0.0%
	Bagasse											-	0.0%
	Wood											-	0.0%
	Briquette/Rice Husk	13,545	95.2%	10374	98.8%	13545	95.2%	84000	99.0%	92400	99.6%	213,864	98.8%
	LPG/Natural Gas											-	0.0%
	LDO/HSD											-	0.0%
	Solar											-	
	Total	14233	100%	10503	100%	14233	100%	84826	100%	92744	100%	216,539	100%

Source: ABPS Infra Research & Analysis

We have estimated specific hot water requirement per day per unit of production based on the data collected from five rice milling industries. We have analysed the data presented in Table 6.2 & 6.3 to develop various scenarios (realistic, optimistic and pessimist) for the major hot water application. We have also considered annual growth rate of 3.3% for the rice milling industry for the next twelve years and estimated maximum possible SWH potential over the next twelve years under the realistic scenario and the same is presented in table 6.4 below:

Rice Mill Industry- SWH Potential Scenario		Realistic
All India Rice Production in Year 2008-09	Mi. T	99.2
% of Rice Producton being processed	%	30%
Rice Mill Industry Growth Rate in India	%	3.30%
Hot water Requirement per day for Direct application per tonne of Rice Processed Annuall	LPD	1.2878
Rice Processing in India in Million tonnes in Base Year FY 10	Million Tonnes	30742080
Overall Hot Water Requirement for Direct Applications in Rice Mill Industry	LPD	39588840
Rice Mill Industry Growth Rate in India for the period FY 2011 to FY 2022	%	3.30%

SWH Scenario ForRice Mill Industry			1	3	5	7	9	11	12
			FY11	FY13	FY15	FY17	FY19	FY21	FY22
All India Rice Processing Capacity	Year On Year	Mi T / Annum	31756569	33887085	36160536	38586510	41175240	43937646	45387588
All India Hot water requirement in Textile Processing	Year On Year	LPD	40895272	43638894	46566584	49690690	53024388	56581742	58448939
All India Hot Water Requirement considering space	**Year On Year**	**LPD**	**72651840**	**77525979**	**82727120**	**88277200**	**94199629**	**100519388**	**103836527**
Year Wise % SWH penetration in Realistic Scenario	Year On Year	%	0.62%	0.62%	0.62%	0.62%	0.62%	0.62%	0.62%
	Cumulative	%	0.62%	1.87%	3.12%	4.37%	5.62%	6.87%	7.49%
Maximum Achievable SWH Penetration in Realistic Scenario	Year On Year	LPD	150318	160403	171164	182647	194901	207977	214840
	Cumulative	LPD	150318	466000	802860	1162320	1545896	1955206	2170046
		M2	3655	11332	19523	28264	37592	47545	52769

Source: ABPS Infra Research & Analysis

We have also estimated overall realisable SWH potential for Rice Milling Industry in terms of LPD & Square Meter of the collector area required for next twelve years under realistic, optimistic and pessimistic scenarios and the same is presented in Table 6.5 below:

Table 6.5: SWH Potential Scenarios in Rice Mill Industry

		FY13	FY17	FY22
Realistic Scenario	LPD	466000	1162320	2170046
	M^2	11332	28264	52769
Optimistic Scenario	LPD	573538	1430548	2670826
	M^2	13947	34787	64947
Pessimistic Scenario	LPD	358461	894093	1669266
	M^2	8717	21742	40592

From the above table, it can be seen that cumulative overall realisable SWH market potential will be 52769 square meter of the collector area in the FY 2022 under the realistic scenario (most likely). We have also estimated state wise SWH potential in Rice Milling Industry by applying % of state wise rice milling production capacity to the all India SWH potential under realistic scenario. State wise realisable SWH market potential for the Rice Milling Industry in India is provided in overall Industrial SWH potential section.

7 SWH POTENTIAL IN TEXTILE PROCESSING INDUSTRY

The textile industry, undoubtedly, one of the most important segments of the Indian economy is on the threshold of the exponential growth. The factors like buoyant domestic economy, conducive policy environment and elimination of quotas in the international market are fuelling its growth raising expectation of an unprecedented capacity expansion.

7.1 Overview of Textile Industry in India

The Indian Textile Industry has an overwhelming presence in the economic life of the country. Apart from providing one of the basic necessities of life, the textile industry also plays a pivotal role through its contribution to the industrial output, employment generation and the export earnings of the country. Currently, it contributes about 14%to Industrial production[6], 4% to the GDP, and 17% to the Country's earnings.

The Indian textile industry can be classified into two categories, organized sector and decentralized sector. Organized sector represents the spinning mills and the composite mills (i.e. spinning, weaving and processing activities carried out in the same premises) whereas decentralised sector constitutes of handloom, power looms, hosiery, fabric processing sector, etc. Small and medium scale textile mills form about 8% of the overall textile sector. Different types of textile mills installed, their installed capacity and actual production details in the year FY 2008-09 are provided in the following table 7.1:

[6] Annual Report 2009-10 – Ministry of Textile, Government of India

Table 7.1: Overview of Textile Industry

Sr. No.	Types of Textile Mills	Units	FY 2008-09
Number of Textile Industries			
1	Spinning Mills (Non - SSI)	No.	1653
2	Spinning Mills (SSI)	No.	1247
3	Composite Mills (Non - SSI)	No.	177
4	Exclusive Weaving Mills (Non - SSI)	No.	184
5	Powerloom Mills	Lakh No.	4.94
6	Processing Units	No.	2510
Installed Capacity			
1	Spindles (SSI & Non-SSI)	Million No.	41.3
2	Rotors (SSI & Non-SSI)	lakh Nos.	6.57
3	Looms (Organised Sector)	Lakh Nos.	0.57
4	Powerloom	Lakh Nos.	22.05
5	Handloom	Lakh Nos.	38.91
Actual Production			
1	Cotton Yarn	Million Kg	2898.42
2	Other Spun Yarn	Million Kg	1015.84
3	Man-made Filament Yarn	Million Kg	1416.01
4	Cotton Fabric	Million Sq. M	26898
5	Blended Fabric	Million Sq. M	6766
6	100% Non-Cotton (Including Khadi, Wool & Silk)	Million Sq. M	20534

Source: www.txcindia.com

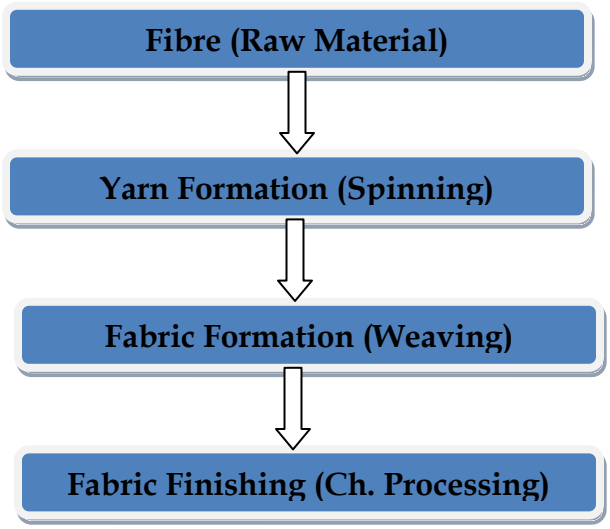
7.2 Textile Process and Energy Consumption

Indian textile industry as a whole is categorized in to three sub-sectors such as Spinning, Weaving and Processing (Industry with combination of any two of this called as composite industry). Fibrous material is the basic raw material for textile. Fibres are broadly classified into two categories:

- Natural Fibres e.g. Cotton, Wool, Silk etc.
- Man-made fibres e.g. polyester, nylon, viscose, acrylic, etc.

Textile process is the process of converting fibres to the finished fabric. The basic flow chart of the textile process is given in the following figure 7.1:

Figure 7.1: Basic Textile Process



7.2.1 Spinning Process:

Spinning process can be divided in to three stages:

- Spinning Preparatory,
- Ring Spinning / Rotor Spinning
- Post Spinning

a) Spinning Preparatory:

Spinning preparatory consists of the following stages:

- Mixing and Blow room: Various fibers are mixed, blended as per requirement in mixing room. In the blow room stage, the mixed fibers are cleaned and converted into lap form.
- Carding: In this stage, the lapped fibersarefurther cleaned and are converted into rope form called 'Sliver'.
- Combing: This process is used for processing long staple fiber to make finer yarn counts. Here short fibers and any remaining foreign material is removed.

- Drawing: In this stage, the carded or combed sliver is drawn to impart uniformity and parallelization of the fibers in longitudinal direction.
- Simplex: In this stage, the fiber in sliver form is converted in to roving form. Now the fiber is ready for spinning.

(b) Ring Spinning / Rotor Spinning:

- Ring Spinning: It is conventional spinning process and is best for medium and fine counts. In this stage, the roving is drafted and twisted in ring frame to convert it into yarn.
- Rotor Spinning (Open end Spinning): In rotor spinning, short staple cotton is converted to coarser count yarn such as 6^{S}, 10^{S}, 20^{S} and 30^{S}.

(c) Post Spinning:

- Winding: In winding machines, the yarn from bobbins from ring frames is wound into larger packs in the shape of cones or cylindrical form.
- Doubling: Here the twisting and doubling of yarn is done as per requirement.

7.2.2 Weaving Process:

Weaving is the process of converting yarn to grey fabric. It involves broadly two stages:

- Weaving Preparatory;
- Weaving (Loom Shed);

(a) Weaving Preparatory:

Weaving preparatory consists of the following stages:

- Warping: Several yarn packages, mounted on a creel are simultaneously unwound and brought together to form a sheet which is wound into a beam called warper's beam.
- Sizing: Several warping beams are placed on a beam creel, unwound and brought together to form a final wrap sheet. Wrap sheet is dipped in size solution, squeezed and dried on cylinders and wound in to weavers beam. The

purpose of sizing stage is to improve the strength and abrasion resistance of the yarn so that it withstands the stresses it encounters on the loom.

(b) Weaving (Loom Shed):

The conventional looms are shuttle looms. But in the modern looms, jets of air or water or small devices called rapiers, projectiles or grippers, do the function of shuttle. These looms are known as air-jet looms, water jet looms, rapier looms or projectile looms, etc. Modern looms are high speed looms. Gray fabric is also prepared on knitting machines called knitted fabric.

7.2.3 Chemical Processing:

The grey cloth available from loom shed needs to be processed further in order to make it acceptable for ultimate end-use. Various chemical treatments are given which enhance the usefulness, appearance and appeal of fabric. Chemical processing of fabric involves various processes as explained in the following:

- Singeing: It burns out the protruding and unwanted fibers from the fabric.
- Desizing: Desizing process removes impurities like starch, gum etc.
- Scouring: the fabric is scoured to remove waxy and oily substances and to improve absorbency.
- Bleaching: it renders the fabric white by removing coloured impurities;
- Mercerizing: Mercerizing process imparts luster and strength to the fabric.
- Dyeing: it imparts colour to the fabric.
- Printing: it creates coloured patterns on the cloth;
- Curing: Curing improves crease recovery properties of cotton fabrics of fixes the pigment colours on the fabric;
- Heat Setting: it imparts dimensional stability to synthetic fabrics of blended fabric;
- Finishing: Finishing improves appearance and feel of the fabric

The main factors, which influence the desired results in chemical processing of the fabric depend on chemical concentration, duration of treatment and the temperature maintained.

Textile industry consumes considerable quantity of thermal as well as electrical energy. Electrical energy is consumed in air compressors, humidification plants and the production machinery in spinning and weaving mills. The study carried out by the Bombay Textile Research Association highlights that humidification plants and air compressors & lighting consume around 20% and 12% of total electrical energy consumption of the spinning mills. Whereas remaining electrical energy (58%) is consumed by the spinning production machinery. Also, weaving mills consume more electrical energy in comparison with thermal energy. Requirement of thermal energy in spinning and weaving mills is limited. Thermal energy i.e. Steam is used for yarn conditioning (twist setting) and sizing in spinning and weaving mills respectively. However, requirement of thermal energy in chemical processing is maximum. Thermal energy is required in fabric processing units for bleaching, dyeing, printing and finishing processes. Electrical energy is used only for driving the motors of various machines in the processing units. As far as usage of hot water is concerned, there is almost negligible scope for the same in spinning and weaving industries. However, in processing industry, hot water is needed for different chemical processes such as desizing, bleaching and dyeing etc. Hence, we have carried out potential assessment of SWHS in the textile processing sector.

7.3 Integrated Textile Parks

Though the Indian Textile Industry has its inherent advantages, infrastructure bottleneck is one of the prime area of concern. To provide the industry with world class infrastructure facilities for setting up their textile units, the Scheme for Integrated Textile Parks (SITP) was launched in 2005 to create new textile parks of international standards at potential growth centres. The aim was to consolidate individual units in a cluster, and also to provide the industry with world class infrastructure facilities using a public private partnership (PPP) model. A total of 30 parks have already been approved during the 10th five-year plan and are currently under development. Taking in to consideration the response to the scheme and opportunities for the growth of the textile sector, the Government of India has continued the SITP in the 11thfive year plan too and approved additional ten textile parks at first instance. We have collected various information such as locations, estimated project cost, government grant sanctioned, government grant released, no. or entrepreneurs, land area, estimated investment, estimated employment, and estimated annual production in (Rs. Crore) for all the forty Integrated Textile parks approved by the Ministry of Textile. These parks would incorporate facilities for all the three sub-sectors like spinning, weaving and processing. However, segregated information related to

number of textile units and its categorisation in spinning, weaving and processing which are likely to come up in each integrated textile parksis not available. Information collected for the forty Integrated Textile Parks is presented in the following table 7.2:

S. no.	Project Name	Location	Estimated project cost Rs Crore	GOI grant (40% of Project cost limited to Rs 40	GOI released upto 30.06.2010 (Rs Crore)	No. of Entrepreneurs	Land Area in Acres	Estimated investment in parks (Rs Crore)	Estimated employment in the park		Estimated annual production (Rs Crore)
									Direct	Indirect	
1	Hyderabad Hi-tech Weaving Park	Mahboob Nagar	58	23.2	12	109	127.85	428.32	10400	20000	450
2	Hindupur Vyapar Apparel Park Limited	Ananthpur	102.27	40	12	171	73.1	265.49	10500	22000	340
3	Pochampally Handloom Park Limited	Pochampally	34	13.6	12.24	28	21.8	27.7	5000	3000	35
4	Brandix India Apparel City Private Limited	Vishakhapatnam	168.77	40	40	17	1000	4878.03	60000	90000	7000
5	MAS Fabric Park (India Ltd	Nellore	254.7	40	12	16	581.68	1982.35	31000	15000	2500
	(5) Andhra Pradesh Total		**617.74**	**156.8**	**88.24**	**341**	**1804.43**	**7581.89**	**116900**	**150000**	**10325**
6	Gujarat Eco Textile Park Limited	Surat	129.92	40	40	33	104.11	705	8000	17000	850
7	Mundra SEZ Textile & Apparel Park Limited	Kutch	131.35	40	36	15	116.24	556.07	10500	15000	740
8	Fairdeal Textile Park Pvt Ltd	Surat	107.25	40	12	53	53.06	312.65	2900	4300	1200
9	Vraj Integrated Textile Park Limited	Kheda	120.02	40	24	21	93.39	579.03	6250	12500	647
10	Sayana Textile Park Ltd	Surat	107.29	40	36	50	56.8	298.61	3155	4733	1312
11	Surat Super Yarn Limited	Surat	100.34	40	36	54	26.93	230.56	1000	2000	1250
12	RJD Integrated Textile Park Ltd	Surat	121.36	40	36	115	55.94	352.69	4270	6405	597.54
	(7) Gujarat Total		**817.53**	**280**	**220**	**341**	**506.47**	**3034.61**	**36075**	**61938**	**6596.54**
13	Metro Hi-Tech Cooperative Park Limited	Ichalkaranji	106.5	40	36	125	74.19	335	5000	5000	200
14	Pride india cooperative Textile park Limited	Ichalkaranji	58.19	23.28	20.95	170	26.4	203.15	1500	2500	225
15	Baramati Hi Tech Textile Park Limited	Baramati	96.72	38.68	34.82	35	60	200.59	5195	5195	347
16	Shri Dhairyashil Mane Textile Park Co-op Societ	Ichalkaranji	72.25	28.9	8.67	167	65	376.55	3300	5000	370
17	Deesan Infrastructure Pvt Ltd	Dhule	139.23	40	12	52	105.74	721.69	4410	6615	2134.53
18	Asmeeta Infratech Pvt Ltd	Bhiwandi	200.8	40	4	65	72.68	662	7634	11451	1045.52
19	Islampur Integrated Textile Park	Islampur	102.4	40	36	12	34.5	334.28	10000	20000	904
20	Latur Integrated Textile Park	Latur	102.61	40	36	20	50	257.42	10000	20000	617.4
21	Purna Global Textiles Park Ltd	Hingoli	91.8	36.72	11.01	41	60.75	159.61	1100	550	200
	(9) Maharashtra Total		**970.5**	**327.58**	**199.45**	**687**	**549.26**	**3250.29**	**48139**	**76311**	**6043.45**

S. no.	Project Name	Location	Estimated project cost Rs Crore	GOI grant (40% of Project cost limited to Rs 40	GOI released upto 30.06.2010 (Rs Crore)	No. of Entrepreneurs	Land Area in Acres	Estimated investment in parks (Rs Crore)	Estimated employment in the park		Estimated annual production (Rs Crore)
22	The Great Indian Linen & Textile Infrastructure	Perundurai	149.45	40	12	20	115	418.05	5000	7500	520
23	SIMA Textile Processing Centre	Cuddalore	111.6	40	6.13	7	247.7	475	5000	15000	500
24	Palladam Hi-Tech Weaving park	Palladam	55.42	22.17	19.95	105	65	161.34	2500	3500	300
25	Komarapalayam Hi-Tech Weaving Park Ltd.	Komarapalayam	34.82	13.93	12.54	57	30.6	125.66	1500	1500	350
26	Karur Integrated Textile Park	Karur	116.1	40	36	42	104	227	3000	4000	623
27	Madurai Integrated Textile Park Ltd	Madurai	87.3	34.92	31.43	17	106	409.76	3000	4000	900
28	Vaigai HiTech Weaving Park	Vaigai, Theni	61.01	24.4	2.44	90	40.64	145.22	2580	3500	361
29	Kanchipuram AACM Handloom Silk Park	Kanchipuram	83.83	33.53	0	115	75	119.86	7000	11000	118
	(8) Tamil Nadu Total		**699.53**	**248.95**	**120.49**	**453**	**783.94**	**2081.89**	**29580**	**50000**	**3672**
30	Jaipur Texweaving Park Limited	Kishangarh	96.81	38.72	23.24	51	94.5	250	3000	9000	550
31	Kishangarh Hi-Tech Textile Park Limited	Kishangarh	101.15	40	24	34	40	407.3	4000	8000	800
32	Next Gen Textile Park Pvt Ltd	Pali	101.4	40	12	53	100	416.18	9450	10000	1050
33	Jaipur Integrated Texcraft Park Pvt Ltd	Jaipur	45.28	18.11	10.86	19	23.36	45.92	4400	8800	90
34	Bharat Fabtex & Corporate Park Pvt Ltd	Pali	103.08	40	4	53	120	416.54	9450	10000	921.51
	(5) Rajasthan Total		**447.72**	**176.83**	**74.1**	**210**	**377.86**	**1535.94**	**30300**	**45800**	**3411.51**
35	Lotus Integrated Tex Park	Barnala	110.26	40	36	8	102	847.71	2400	2950	1740
36	Rhythm Textile & Apparel Park Ltd	Nawanshehar	125.46	40	12	14	18.5	339.84	11000	14000	350
37	Ludhiana Integrated Textile Park Ltd	Ludhiana	116.19	40	4	55	57.16	217	10000	10000	500
	(3)Punjab		**351.91**	**120**	**52**	**77**	**177.66**	**1404.55**	**23400**	**26950**	**2590**
38	EIGMEFApparel Park Limited	Kolkata	104.59	40	24	73	12.88	140	11600	34800	180
39	Doddabalapur Integerated Textile Park	Doddabalapur, K	84.92	33.96	30.56	90	48	132.73	2000	2000	350
40	CLC Textiile Park Pvt Ltd	Chhindwara, MP	88.92	35.57	3.56	20	47.47	295	2000	1000	400
	Total (40)		**4183.36**	**1419.69**	**812.4**	**2292**	**4307.97**	**19456.9**	**299994**	**448799**	**33568.5**
	Source: Ministry of Textile, Government of India & Data as on August, 2010										

7.4 Textile Processing Industry

The processing stage is undoubtedly the most significant process in the value chain of various textile products contributing to essential user requirements and also aesthetic value. In the global scenario, the value addition at this stage of production is maximum, often manifold. However, in India, the processing stage is considered as, perhaps the weakest link in the entire textile production chain, which results in loss of potential value addition and also valuable foreign exchange earnings. To export value-added goods and to cater to the requirements of the export-oriented clothing sector quality, goods have to be produced uniformly and consistently at the very first time and re-processing has to be avoided /minimized. The processing industry, which has been recognized as one of the weakest links in the textile value chain needs to be supported and upgraded to facilitate processing of products acceptable at international level.

There has been significant improvement in the processing sector during the Tenth Plan period. The contributory factorsare'Technology Up-gradation Fund' and removal of the differential excise duty structure. The census of the power processing units by the Textiles Committee during the year 2005 has revealed that there were 2510 power processing units in the country compared to 2324 units in 1999-2000. The overall increase during the period was 8 percent. Out of the 2510 power processing units, 59 units are composite, 167 semi-composite and 2284 the independent processing units.

During the Tenth Plan the share of the power processed fabric has increased from 30% to 68%. Now only about 22% of the fabric is hand processed and 10% is sold in a grey form. The Textiles Committee survey has also revealed that there are 189 units having facility of continuous processing of fabrics of 50,000 meters and above per day. The production of textile processing units was 9.1 billion m^2 during 2005-06 with 5 year CAGR of 15.43%. Working group report on Textile and Jute Industry for the 11^{th}five year plan estimate production of textile processing industry would be around 38 billion sq. mtr. by the end of Eleventh plan.

Textile processing units are spread across the entire country. The major clusters of processing units identified by Office of the Textile Commissioner and Ministry of Textile are Tirupur, Jodhpur, Surat, PaliMarwar, Jetpur, Balotra, Bhiwandi, Tarapur, Navi Mumbai, Badlapur,

Dombivali, Amritsar, Kanpur, Ludhiana, Hyderabd, Nagari and Sircilla. We have provided brief about some of the important clusters below:

- **Tirupur Cluster:**

The textile cluster at Tirupur is spread across the town and there are as many as 2000 plus units, large and small engaged in some or other business of textiles such as knitting, garment manufacturing, embroidery, dyeing and bleaching. It is the largest textile cluster consisting of 100% export oriented units. The units run in a single shift, certain units which are having direct link with the export houses run in 2/3 shifts. There is an acute power shortage, daily cuts of 30 - 45 min for 2/3 times in a day. Majority of the fabric manufacturing units – grey fabric wherein looms are operating do not have an power back up system, certain knitting units have power back up systems since they are associated with export house. The units are mainly into knitting – T shirt manufacturing, Hosiery. Besides this with export business increasing number of embroidery – computer aided embroidery have also started coming up. Currently there are over 250 embroidery units in this cluster. The major equipments are looms, sewing machines operated by motors as well as computed aided embroidery. The raw material required for thread, fabric and yarn are 58245, 301933 and 146050 tonnes respectively. The annual energy requirement of the cluster is 1250 Lac Units of electricity and 117 Lac litres of HSD.

- **Surat Cluster:**

Surat, an emerging city in the State of Gujarat, is known as the textile city of Gujarat. Textile industry is one of the oldest and the most widespread industries in Surat. The industrial area in Surat is mainly occupied by textile industries. The textile industries in Surat are associated with production of yarn as well as processing of Fabric, jari works & Embroidery works. Main Industrial areas are Sachin, Pandesara, Katodana&Palsana as well as Udhana. There are around 200 units of textile processing in Sachin, 200 in Pandesara, approximately 100 units in Katodana and some 100 spread across Palsana&Udhana. Maximum units are functioning from 15 to 20 years & all are mechanised. The major raw material (grey cloth) is being procured from local Manufacturer / traders. Energy cost is about 12 to 15% of the total production cost. Labour is not a problem as migratory labour is easily available. Majority of the units are purchasing grey fabric, on an average the roll is 100 meter & the average processing time is 2 to 5 hours. There are certain units, process houses which are completely integrated houses starting from yarn to

fabric to dyeing/printing, finishing but majority of the units are into dyeing /printing of grey fabric – cotton, viscose, synthetic.

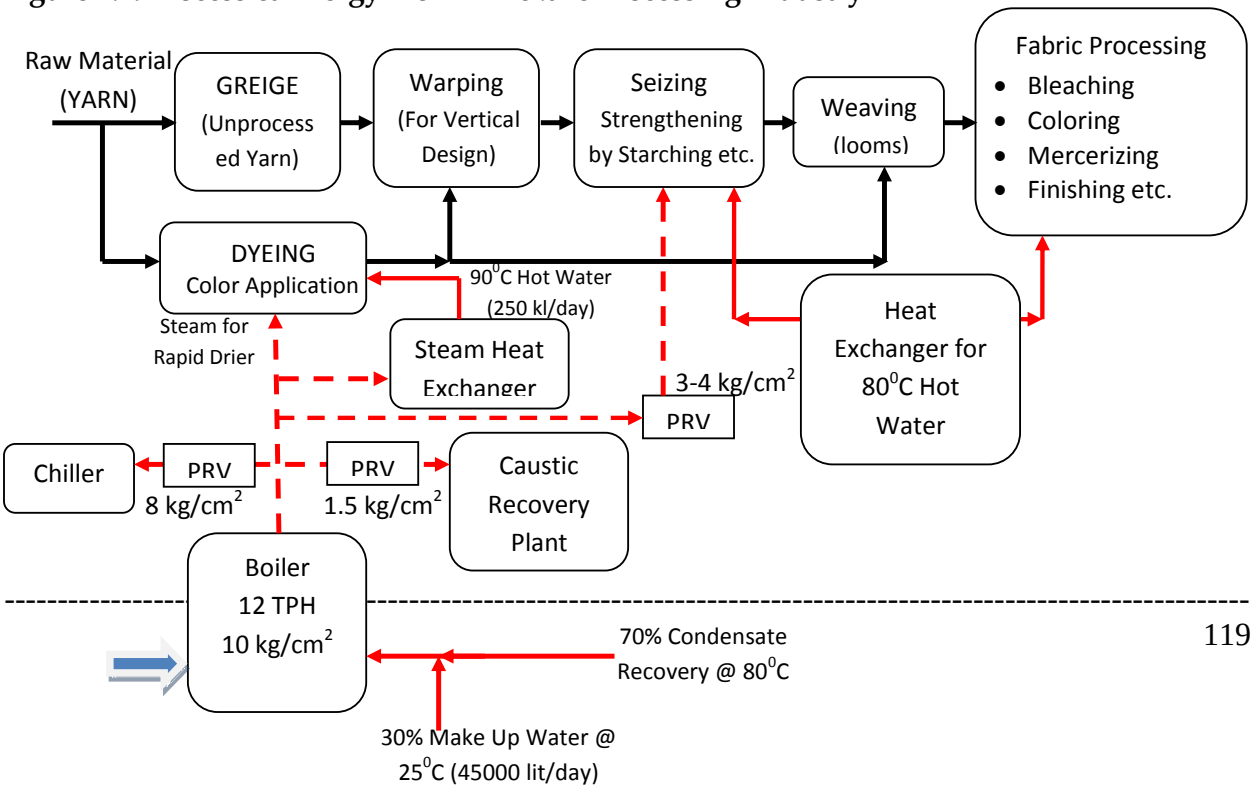
- **Ludhiana:**

Ludhiana is located in the State of Punjab, around 300 Kms from the National Capital Territory of Delhi. Textile processing units are situated at city center, focal points near Sherpur Road, Mothi Nagar, Rahon Road and Jalandhar Bye pass. Textile processing activities in the cluster provide direct employment to around 35000 persons of, which 70% are employed at small scale level and rest in organised composite mills. Textile processing units in Ludhiana cluster are mainly classified as fiber dyeing unit, package yarn dyeing unit, hank yarn dyeing unit, knit fabric dyeing unit, woven fabric dyeing unit and made up units, printing units and finishing units etc. Ludhiana now produces all type of textile products such as woven products (Shawls, blankets, shirting & suiting etc) and knit wear products (Jerseys, Mufflers, Jackets etc).

7.4.1 Textile Processing Industry Process and Integration of SWHS

Textile processing is a general term that covers right from singeing (protruding fiber removal) to finishing and printing of fabric. A typical process flow diagram of Textile Processing Industry is presented in below figure 7.2:

Figure 7.2: Process & Energy Flow in Textile Processing Industry



As indicated in Figure 7.2, singeing is the process of removing the pills and protruding fibre of the fabric coming from weaving. This operation may either be done at the beginning of the process or at the end of the finishing operation and is followed by de-sizing. De-sizing of fabric is essential to remove the sizing materials added during warping to strengthen the warp yarns. This size if present during subsequent processing will affect the quality of look and finish. De-sizing can be done as either Acid De-sizing, an old process of destroying the starch and other size materials in the presence of acid at elevated temperatures or Oxidative De-sizing with the help of an oxidizing agent such as Hydrogen peroxide or Enzymatic De-sizing which is bio degradation method that destroys starch and other sizing materials in to soluble form that will be washed off during subsequent washes.

Among textile processes, bleaching is another important process to make the fabric or yarn look brighter and whiter. This is achieved by oxidizing or reducing the coloring matters in to colourless form. Most widely used textile bleaching method is Hydrogen Peroxide bleaching. This is carried out in an alkaline bath at about 80 to 85°C at a pH of 11.Textile processing also involves other processes like strenting, bleaching,coloring, mercerizing, polymerizing, which require steam and hot water. Most of the hot water requirement in textile processing industry is in the range of 70 to 90°C and can be provided using SWHs.

7.4.2 Realisable SWH Potential in Textile Processing Industry

In Textile Processing Industry, direct SWH application is to heat make up water, however the quantity varies depending upon the boiler size and % condensate recovery. In addition to this there is large scope for direct SWH application in various sections such as dyeing, bleaching, etc. In order to quantify the potential in Textile Processing Industry, we visited ten textile industries in two clusters viz. Maharashtra and Tirupur (Coimbatore) for the collection of primary information and data. Out of ten mills, five mills are spinning and weaving mills whereas remaining five mills are processing mills. Though hot water is required for various processes such as bleaching, dyeing in processing units, hot water requirement is almost

negligible in Spinning &Weaving mills. In order to strengthen the findings of the study, we collected data for additional 5 textile processing industries from the Bombay Textile Research Association (BTRA). We have also collected data for different types of fuel used by the ten industries in order to meet its thermal and electrical energy requirements for the various process applications. Primary data collected from ten textile processing industries and different types of fuels used by these industries are provided in the table 7.3 &7.4 respectively.

Table7.3 : Hot Water requirement in Textile Processing Industry and Land Availability

Industry Name			Raymod limited	Jayvishnu Textile	Kongoor Textile	Global Textil	G.M.S Process	Processing - M-1	Processing M-2	Composite M-1	Composite MP-1	Processing M-3	Overall Parameters
Co-Generation Status			No	No	No	No	No	No	No	No	Yes	No	
Production (meters/ Annum)			10570305	10000000	9600000	416000	6320000	32000000	24918720	22750000	9084900	24000000	159659925
Solar Potential For Boiler Feed Water Heating	Temp (0C)	Reqd	80	80	80	80	95	80	80	80	80	80	80-95
		Possi.	80	80	80	80	80	80	80	80	80	80	80
	Hot Water Quantity (LPD)		45000	12000	6000	19200	2880	43200	24000	14400	13920	25000	205600
Solar Potential For Process Heating (DH Hot water Application)	Temp (0C)	Requ	90	70	95	98	75	85	85	85	80	80	70-98
		Poss.	80	70	80	80	75	80	80	80	80	80	70-80
	Hot Water Quantity (LPD)		250000	209000	200000	200000	180000	400000	300000	273890	109374	300000	2422265
Solar Potential HAGen.	Hot Water Quantity (LPD)			764305									764305
Overall Swh Potential For Industries Surveyed			295000	221000	206000	219200	182880	443200	324000	288290	123294	325000	2627865
Estimated Land Requirement for SWH Installtion (Acres)			2.33	1.75	1.63	1.73	1.45	3.50	2.56	2.28	0.97	2.57	20.77
Land Available for SWH installation			1.2	1	0.8	1	0.75	1.5	0.8	1	0.4	1	9.45
Max. Imp. SWH Potential After Space Constraint	SWH Capacity (LPD)		151840	126533	101226.4	126533	94899.75	189799.5	101226.4	126533	50613.2	126533	1195736.85
	% of Total Potential		51.5%	57.3%	49.1%	57.7%	51.9%	42.8%	31.2%	43.9%	41.1%	38.9%	45.50%

Table 7.4 **Different Types of Fuels Used in Textile Processing Industry**

Industry Name		Raymond Zambaiti Limited		Jayvishnu Textile Processer Private Limited		Kongoor Textile Processing Limited		Global Textile Processing Limited		G.M.S Processor Private Limited		Processing - M-1		Processing M-2		Composite M-1		Composite MP-1		Processing M-3		Overall Parameters	
	Energy Source	**Mk Cal**	**% of Total**	**Mk Cal**	**% of Total**	**Mk Cal**	**% of Total**	**Mk Cal**	**% of Total**	**Mk Cal**	**% of Total**	**MkCal**	**% of Total**	**Mk Cal**	**% of Total**	**Mk Cal**	**% of Total**	**MkCal**	**% of Total**	**Mk Cal**	**% of Total**	**MkCal**	**% of Total**
Energy Utilised From Different energy Sources (Million kCal)	Electricity	16,271	25.4%	1032	7.1%	946	3.5%	430	3.9%	826	9.7%	9976	0.0%	7434	1.1%	16511	8.3%	33254	0.1%	3287	1.6%	86,680	0.1%
	Ind. Coal	12,054	18.8%									25200	0.1%	30542	4.5%			14842800	41%	49468	23.9%	14,960,064	18.1%
	Imp. Coal	34,997	54.6%																			34,997	0.0%
	FO											45080000	100%					21256200	59%			66,336,200	80.5%
	Rice Husk															44940	23%					44,940	0.1%
	Wood			13600	92.9%	26369	96.5%			6267	73.3%		0.0%									46,236	0.1%
	Coconut Waste							10465	96.1%	1457	17.0%											11,922	0.0%
	LPG/Natural Gas													639027	94.4%	136800	69.0%			153860	74.5%	929,687	1.1%
	LDO/HSD	752	1.2%																			752	0.0%
	Solar																					-	
	Total	**64075**	**100%**	**14632**	**100%**	**27315**	**100%**	**10895**	**100%**	**8550**	**100%**	**45115176**	**100%**	**677004**	**100%**	**198251**	**100%**	**36132254**	**100%**	**206615**	**100%**	82,454,766	**100%**

Textile Processing Industries which are located in the Coimbatore utilise wood, coconut waste and electricity in order to meet thermal and electrical energy requirement of the processing industries, whereas processing industries which are located in Maharashtra and Madhya Pradesh clusters utilise Indian / imported coal and Furnace Oil. We have estimated specific hot water requirement per day per unit of fabric processed annually based on the data collected from the ten textile processing industries. We have analysed the data presented in table 7.3 & 7.4 to develop various scenarios (realistic, optimistic and pessimist) for the major hot water applications. As per Working group report on Textile and Jute Industry for the 11th five year plan, production of textile processing industries will increase from 9.1 billion m2 during 2005-06 to 38 billion sq. Mtr by the end of eleventh plan. However, we have considered only annual growth rate of 10% for the textile processing industries for the estimation of maximum possible SWH penetration over the next twelve years. Maximum SWH penetration over the next twelve years in realistic scenario is provided in table 7.5 below:

Textile Processing Industry- SWH Potential Scenario		Realistic
All India Annual Capacity of Textile Processing Industry in year 2005-2006	Billion Mt	9.1
Textile Processing Industry Growth Rate in India	%	15.43%
Hot water Requirement per day for Direct application per meter of Fabric Processed Annually	LPD	0.0165
All India Annual Capacity of Textile Processing Industry in Base Year FY 11	mtr/Annum	1.616E+10
Overall Hot Water Requirement for Direct Applications in Textile Processing Industry	LPD	265903028
Textile Processing Sector Growth rate in India during 2011-2022 (Assumed)	%	10.00%

SWH Scenario For Textile Processing Industry			1	3	5	7	9	11	12
			FY11	FY13	FY15	FY17	FY19	FY21	FY22
All India Textile Processing Capacity	Year On Year	mt/annum	17770876966	21502761129	26018340966	31482192569	38093453008	46093078140	50702385954
All India Hot water requirement in Textile Processing Industry	Year On Year	LPD	292493331	353916931	428239486	518169778	626985431	758652372	834517609
All India Hot Water Requirement considering space constraints	Year On Year	LPD	103103638	124755402	150954036	182654384	221011805	267424284	294166712
Year Wise % SWH penetration in Realistic Scenario	Year On Year	%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%	0.95%
	Cumulative	%	0.95%	2.85%	4.76%	6.66%	8.56%	10.46%	11.41%
Maximum Achievable SWH Penetration in Realistic Scenario	Year On Year	LPD	980617	1186547	1435721	1737223	2102040	2543468	2797815
	Cumulative	LPD	980617	3245842	5986765	9303281	13316265	18171977	20969791
		M2	23846	78930	145581	226230	323814	441892	509927

Source: ABPS Infra Research & Analysis

We have also carried out estimation ofoverall realisable SWH potential for Textile Processing Industries in terms of LPD and Square Meter of the collector area required for the next twelve years under three different scenarios and the same is presented in Table 7.6 below:

Table 7.6: SWH Potential Scenarios in Textile Processing Industry

		FY13	FY17	FY22
Realistic Scenario	LPD	3245842	9303281	20969791
	M^2	78930	226230	509927
Optimistic Scenario	LPD	3994883	11450192	25808974
	M^2	97144	278437	627602
Pessimistic Scenario	LPD	2496802	7156370	16130609
	M^2	60715	174023	392251

Cumulative overall realisable SWH potential for the Textile Processing Industry under realistic scenario will be around 509927 Square Meter in the year FY 2022. States like Tamil Nadu, Maharashtra and Gujarat offers more than 60% of potential out of total realisable SWH potential in the Textile Processing Industrial sector.

8 SWH POTENTIAL IN PHARMACEUTICAL INDUSTRY

The global pharma market is estimated at US$ 773 billion, of which the US accounts for 38%. This share is expected to decrease to 34% by 2013, when drug sales will reach $987 billion. The global market for generic drugs was estimated to be worth US$ 83 billion in 2009, of which the US accounted for about 42%.

8.1 Overview of Pharmaceutical Industry in India

The Indian Pharmaceutical Industry is ranked 3rd in the world in terms of production volume and 14th in terms of domestic consumption value. The Indian Pharmaceutical Industry was estimated at $ 19.4 Bn in FY 2009. Formulation accounts for 65% and bulk drugs for balance 35% in value terms. As per research carried out by IMS Health, Crisil Research and Tata Strategic, this industry is expected to reach $ 43.8 Bn in FY 2014. Bulk drugs exports are expected to grow fastest at 35% followed by formulation exports at 25%. The domestic formulation market is expected to grow at 11% with key growth drivers being increased per capita spend on pharmaceuticals, improved medical infrastructure, greater health insurance penetration and increasing prevalence of lifestyle dieses. Today, the Indian Pharmaceutical sector is able to meet 95% of the country's medical needs. The Indian Pharmaceutical industry consists of both domestic companies and subsidiaries of multinational operations. Indian companies manufacture a wide range of generic drugs (branded and non-branded), intermediates and bulk drugs/Active Pharmaceutical Ingredients (API).

8.1.1 Indian Formulation Industry

Formulations are broadly categorised in to patented drugs and generic drugs. A patented drug is innovative formulation that is patented for a period of time (usually 20 years) from the date of its approval. A generic drug is a copy of an expired patented drugs that is similar in dosage, safety, strength, method of consumption, performance and intended use. Patented drugs are usually imported while most of the generic drugs are manufactured domestically.

The Indian Formulation market is estimated to be $ 12.6 Bn in FY 09 comprising of domestic consumption of $ 7.6 Bn and exports of $ 5 Bn. Crisil Research and Tata Strategic estimated that the formulation market is expected to grow at 17% CAGR to reach $ 25.6 Bn in FY 2014. Over 40% of total formulations exports from India is to regulated markets and this split is expected to

continue at the same level going forward. Over the last thirty years, India's pharmaceutical industry has evolved from being a marginal global player to becoming a world leader in the production of high quality generic drugs. India exports pharmaceutical products to more than 200 countries primarily the United States, Russia, China and the United Kingdom.

India currently represents just U.S. $6 billion of the $550 billion global pharmaceutical industry but its share is increasing at 10% a year, compared to 7% annual growth for the world market. Also, while India represents just 8% of total global industry by volume, putting it in fourth place worldwide, it accounts for 13% by value and drug exports have been growing 30% p.a. Approximately 95% of India's demand for medicines is met by local manufacturing. The formulation industry is highly fragmented and has a range of over 100,000 drugs spanning various therapeutic segments.

8.1.2 Indian Bulk Drug Industry

Bulk drugs/ API are the key ingredients for making formulations. Bulk drugs export account for 90% of bulk drug production in India. Bulk drug exports from India have grown from $ 1.5 Bn in FY 2004 to $ 6.7 Bn in FY 2009 at a CAGR of 35%. 90% of Bulk drugs manufactured in India cater to the export market. Majority of the growth is expected to be from the rising exports to regulated markets like USA, Europe and Japan. As per the research carried out by Crisil, the share of API exports to innovator companies in regulated market is expected to increase from 8% of total exports in FY 09 to 17% by FY 14. This rise is expected to be driven by the strongest patent safeguards being adopted by India and increasing confidence of foreign players in the Indian Regulatory framework and technical capabilities.

The technical competency of the Indian manufacturers compared to the other nations can be gauged by number of Drug Master Files (DMFs) filed. Over the period 2000 to 2009, India has filed largest number of DMFs as compared to various countries like China and Italy.

8.2 Major Pharmaceutical Clusters in India

India has grown in to the major players in the Pharma manufacturing sector. As per National Pharmaceutical Pricing Authority (NPPA), Government of India, there are around 10563 pharmaceutical manufacturers available across the country. These manufacturing units have been divided into two broad categories viz. 'formulations' and 'bulk drugs'. Out of 10563 manufacturing units, 8174 (77.4%) units' manufacturer formulations drugs and remaining 22.6%

units are engaged in manufacturing of bulk drugs. Five States such as Maharashtra, Gujarat, Andhra Pradesh, Tamil Nadu and West Bengal have more than 60% share in terms of number of pharmaceutical industries.

Manufacturing units which are involved in formulations are largely concentrated in West and South India, primarily Maharashtra, Gujarat and Andhra Pradesh. However, many players shifted their manufacturing base to excise free zones in the North such as Baddi (Himachal Pradesh), Haridwar (Uttrakhand) and Sikkim due to incentives offered by the government. Manufacturing units, which are involved in bulk drug manufacturing are primarily located in Gujarat (Ahmedabad, Ankleshwar, Vapi&Vadodara), Maharashtra (Mumbai, Tarapur, Aurangabad &Pune), Andhra Pradesh (Hyderabd and Medak) and Tamil Nadu (Chennai &Pondichery). State wise distribution of pharmaceutical units is provided in the figure 10.1:

Figure 8.1: State Wise Distribution of Pharmaceutical Units in India

Source: National Pharmaceutical Pricing Authority, Government of India

- **Maharashtra Pharmaceutical Cluster**:

Maharashtra accounts for approximately 18% of the country's output of pharmaceuticals by value. The Major pharma clusters in the state are Pune, Nashik, Aurangabad and Mumbai. The state is the leading producer of vaccines in the country. Major pharmaceutical units such as Pfizer, Johnson and Johnson, GlaxoSmithKline, Abbott, Sun Pharmaceutical Industries etc. have their presence in the state. Maharashtra's strong position is displayed with around 3,139 manufacturing licensees. The total FDI investment in the pharmaceutical sector till January 2010 was USD 216 million. Maharashtra has a strong skilled labor base supporting the pharmaceutical industry. The state offers a strong educational infrastructure with technical institutions providing pharmaceutical courses across the state.

8.3 Pharmaceutical Industry Process and Integration of SWHS

Most of the pharmaceutical industrial units visited during market research phase, produce multiple products such as Tablets, Capsules, Ointments, Liquids and Powder. Requirement of the thermal and electrical energy varies from industry to industry based on the variation in the production of the abovementioned products. Various steps involved in the manufacturing of abovementioned products are presented below in brief:

Capsule Manufacturing Process: Capsules are generally powder in hard gelatine. The process is performed in negative pressure zone thus not contaminating other area. In capsule manufacturing, the different raw materials are mixed in closed vessel, called blender. The dry powder or pellets are then filled in to hard gelatine capsule with the help of semi automatic or fully automatic machines. The process of mixing and filling produces very negligible amount of contaminants. The filled capsules are then inspected, polished to sort out the defective ones. The good ones are packed into blister or strips to protect from atmosphere. Hot water requirement during capsule manufacturing process is almost negligible except for cleaning of utensils.

Ointment Manufacturing Process: The ointments are manufactured in negative pressure zone thus not contaminating other areas. Some raw materials are mixed in water phase and some are in wax phase in manufacturing vessels. Both the solutions are mixed together in manufacturing tank and ointments / creams are prepared. The mass is called bulk. The bulk after release from Quality Control (Q.C.) department is filled in Aluminium/ Laminated tubes by filling and

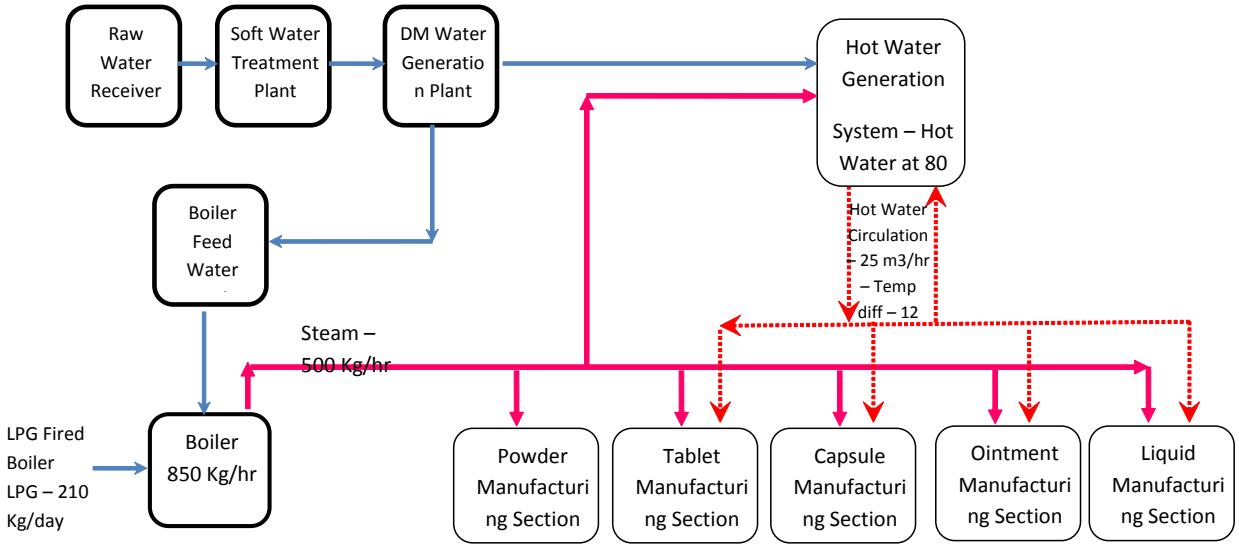
sealing machine and finally packed in cartons by catonator machines. In order to mix the raw materials in water phase, hot water is required in ointment manufacturing process.

Liquid Manufacturing Process: Sugar syrup prepared in syrup preparation tank under heat. Hot water is being utilised for the preparation of the sugar syrup. The syrup after cooling to room temperature transferred in manufacturing tank. All other raw materials are added with proper sequence under constant stirring. The prepared syrup is than filtered through sparkler filter and kept in storage tank. The prepared syrup is called bulk. The bulk is sent to Q.C. for release for filling and packaging operation. The bulk is transferred to filling and sealing machine which is then filled and sealed in bottles, labelled, packed in unit carton.

Powder Manufacturing Process: Power is also manufactured in negative pressure zone thus not contaminating the other areas. In manufacturing process, the sugar is pulverized, all other raw materials are sifted and mixed together in blender. Trace elements are dissolved in solvent, soaked in inert materials and dried in over before mixing in blender. The blended material is called bulk. The bulk is then sent to Q.C. for release for packing operation. The powder is filled in poly laminated Aluminium foils, the pouches then packed in printed tins, sealed and finally packed in corrugated boxes.

Most of the utilities such as hot water generation system, boiler, and chilled plant for process cooling as well as comfort cooling are common and centralised. Typical process & energy flow for one the pharmaceutical industry visited is provided in Figure 8.2 below:

Figure 8.2 : Process & Energy Flow in Pharmaceutical Industry



Steam is generated in LPG / Natural Gas fired boiler in order to meet the heating requirement of the production facilities. Steam is mainly utilised in hot water generation system and dryers for the generation of hot water and hot air respectively. Hot water at 80°C is generated with the help of steam. One hot water circulation pump is running continuously in order to fulfil hot water requirement of the various manufacturing sections through supply and return header. Once the level in the hot water system is reduced, DM water pump feeds the equivalent quantity of fresh water to the hot water generation system. Condensate is also recovered and sent back to boiler feed water tank. Make up water is also fed to the boiler feed water tank at the regular interval. However, quantity of makeup water varies from industry to industry based on the percentage of condensate recovered.

8.4 Realisable SWH Potential in Pharmaceutical Industry

The Pharmaceutical Industry has ample potential for direct SWH application in process to make the syrups. Also for those pharmaceutical industries, which are using boiler for hot water generation, there is scope for direct SWH application for makeup water heating. Some of the pharmaceutical industries also need hot air at around 60 to 80°C, which can be generated

through indirect SWH application. We visited four pharmaceutical industries located in the Dehradun (Uttrakhand) during primary data collection phase. We have also collected similar data for two more pharmaceutical industries located in the State of Maharashtra from the Energy Auditing Agency. Based on the collected information for six industries, we have carried out assessment of maximum implementable SWH potential after considering space constraint. Information collected from six Pharmaceutical Industries is provided in Table 8.1 below. In addition to the primary information, we have also collected information pertaining to the different types of fuel used in these six industries andthesame is presented in table 8.2 below:

Table 8.1: Hot Water Requirement in Pharmaceutical Industries and Land Availability

Industry Name			Coral Laboratories Limited	India Glycol Limited	Suncare Formulations Private Limited	Troikaa Pharmaceuticals Limited	Pharma M - 1	Pharma M - 2	Overall Parameters
Co-Generation Status			No	No	No	No	No	No	
Industry No			1	1	1	1	1	1	6
Solar Potential For Boiler Feed Water Heating	Temp (0C)	Required	80	80		80	80	80	80
		Possible	80	80		80	80	80	80
	Hot Water Quantity (LPD)		3000	9600		7500	15600	12000	47700
Solar Potential For Process Heating (Direct Hot water Application)	Temp (0C)	Required	80	80	80	110	80	80	80 - 110
		Possible	80	80	80	80	80	80	80
	Hot Water Quantity (LPD)		13000	12000	6000	22000	15000	17000	85000
Solar Potential For Hot Air Generation	Quantity of HOT Air (m3/hr)		21654	0	3871	4812			
	Temp (0C)	Required	70		80	80			70-80
		Possible	70		80	80			70-80
	Hot Water Quantity (LPD)		47196		8436	31464			87096
Overall Swh Potential For Industries Surveyed			63196	21600	14436	60964	30600	29000	219796
Estimated Land Requirement for SWH Installtion (Acres)			0.50	0.17	0.11	0.48	0.24	0.23	1.74
Land Available for SWH installation			0.2	0.25	0.1	0.5	0.1	0.1	1.25
Maximum Implementable SWH Potential After	SWH Capacity (LPD)		25307	21600	12653.3	60964	12653.3	12653.3	145830.5
	% of Total Potential		40.0%	100.0%	87.7%	100.0%	41.4%	43.6%	66.35%

Source: ABPS Infra Research & Analysis

Table 8.2: Different Types of Fuels Used in Pharmaceutical Industry

Industry Name		Coral Laboratories Limited		India Glycol Limited		Suncare Formulations Private Limited		Troikaa Pharmaceuticals Limited		Pharma M - 1		Pharma M - 2		Overall Parameters	
Energy Utilised From Different energy Sources (Million kCal)	Energy Source	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	%of Total	MkCal	% of Total	MkCal	% of Total
	Electricity	774	65.9%	2580	29.0%	226	63.0%	886	14.3%	4782	42.3%	886	14.3%	5,352	23.5%
	Indian Coal													-	0.0%
	Imported Coal													-	0.0%
	FO													-	0.0%
	Bagasse													-	0.0%
	Wood													-	0.0%
	Briquette/Rice Husk												0.0%	-	0.0%
	LPG	400	34.1%					5292	85.7%					5,692	25.0%
	LDO/HSD			6329	71.0%	133	37.0%			6528	57.7%	5292	85.7%	11,754	51.6%
	Solar													-	
	Total	1174	100%	8909	100%	358	100%	6178	100%	11310	100%	6178	100%	22,797	100%

Source: ABPS Infra Research & Analysis

Pharmaceutical Industry is required to maintain good hygiene conditions, hence utilize clean fuels such as LPG and electricity to cater to thermal energy requirement of the production processes.We have estimated specific hot water requirement per unit of pharmaceutical industry based on the data collected from the six pharmaceutical industries. Since, Pharmaceutical industries manufacturer wide variety of products, we have done our analysis based on the number of units installed in different States in India. We have analysed the data presented in table 8.1 and 8.2 to develop various scenarios (realistic, optimistic and pessimistic) for the major hot water applications. We have also considered 3% increase in number of pharmaceutical industries every year for estimation of maximum SWH potential over the next twelve years. Maximum SWH penetration over the next twelve years in realistic scenario is provided in table 8.3 below:

Pharmaceutical & Drugs Industry- SWH Potential Scenario		Realistic
Number of Pharmaceutical Industrial installed in India in 2009-10	No.	10032
Peccentage Of Pharmaceutical Industry Requiring Hot Water	%	20%
Average Hot water Requirement per day for Direct application For Pharmaceutical Industr	LPD	36633
Number of Pharmaceutical Industries in India in Base Year FY 10	Numbers	10032
Overall Hot Water Requirement for Direct Applications in Pharmaceutical Industry	LPD	73499782
Increase in Number of Pharmaceutical Industry (growth rate) for the period 2011-2022	%	3.00%

SWH Scenario For Pharmaceutical Industry			1	3	5	7	9	11	12
			FY11	FY13	FY15	FY17	FY19	FY21	FY22
All India Number of Installed Pharmaceutical Indust	Year On Year	No	10333	10962	11630	12338	13089	13887	14303
	Cumulative	No	10333	31938	54859	55567	81365	108734	123037
All India Hot water requirement in Pharmaceutical Industry	Year On Year	LPD	75704776	80315197	85206392	90395461	95900545	101740888	104793115
	Cumulative	LPD	75704776	233995892	401926937	407116006	596123876	796642326	901435441
All India Hot Water Requirement considering space constraints	Year On Year	LPD	75715109	80326159	85218022	90407800	95913635	101754775	104807418
	Cumulative	LPD	75715109	234027830	401981796	407171573	596205241	796751060	901558478
Year Wise % SWH penetration in Realistic Scenario	Year On Year	%	2.71%	2.71%	2.71%	2.71%	2.71%	2.71%	2.71%
	Cumulative	%	2.71%	8.13%	13.54%	18.96%	24.38%	29.79%	32.50%
Maximum Achievable SWH Penetration in Realistic Scenario	Year On Year	LPD	1360360	1443206	1531098	1624341	1723264	1828211	1883057
	Cumulative	LPD	1360360	4204738	7222338	10423710	13820045	17423218	19306275
		M2	33080	102247	175627	253475	336065	423684	469475

Source: ABPS Infra Research & Analysis

We have also estimated overall realisable SWH potential for Pharmaceutical Industry in terms of LPD & Square Meter of the collector area required for next twelve years under realistic, optimistic and pessimistic scenarios and the same is presented in Table 8.4 below:

Table 8.4: SWH Potential Scenarios in Pharmaceutical Industry

		FY13	FY17	FY22
Realistic Scenario	LPD	420473	10423710	19306275
	M^2	102247	253475	469475
Optimistic Scenario	LPD	517506	12829181	23761569
	M^2	125843	311970	577815
Pessimistic Scenario	LPD	323441	8018238	14850981
	M^2	78652	194981	361134

From the above table, it can be seen that cumulative overall realisable SWH market potential will be 469475 square meter of the collector area in the FY 2022 under the realistic scenario (most likely). State wise SWH potential in Pharmaceutical industry is estimated by applying % of state wise pharmaceutical industries to the all India SWH potential of Realistic (Most Likely) scenario. States like Gujarat and Maharashtra offer around 45-50% of potential out of total realisable SWH potential in the Pharmaceutical Industry in India. State wise realisable SWH market potential for the Pharmaceutical Industry in India is provided in overall Industrial SWH potential section.

9 SWH POTENTIAL IN PULP AND PAPER INDUSTRY

Consumption of paper is considered as an indicator of economic growth of the country. An improvement in the standard of living results in increase in demand for better quality paper. With economic development and better living standards, it is expected that demand for high-end varieties of paper will increase.

9.1 Overview of Pulp and Paper Industry in India

Paper performs a range of core functions in the modern world. For many it would be hard to imagine daily life without using paper, whether for communication, packaging or for hygiene and household usages. The steady growth in paper consumption has confirmed its utility as a low cost, high performance and flexible material. Official publications and public opinion surveys both confirm that paper is regarded as "essential" for development and modern living. Per capita consumption of paper is considered as one of the indicators of socio-economic development of any country. As per the study carried out by Central Pulp and Paper Research Institute, the consumption of paper in India is abysmally low at 8.3 kg / annum in comparison to 337 kg in USA, 250 kg in Japan, 110 kg in Europe, 30 kg in China and 54 kg as World average. Compared to this, India's per capita consumption is one of the lowest in the world.

As per the Indian Paper Manufacturing Association (IPMA), the Indian Paper Industry accounts for about 1.6% of the world's production of paper and paperboard. The estimated turnover of the industry is Rs 25,000 crore (USD 5.95 billion) approximately and its contribution to the exchequer is around Rs. 2918 crore (USD 0.69 billion). The industry provides employment to more than 0.12 million people directly and 0.34 million people indirectly. The industry was delicenced effective from July, 1997 by the Government of India; foreign participation is permissible. Most of the paper mills are in existence for a long time and hence present technologies fall in a wide spectrum ranging from oldest to the most modern.

The mills use a variety of raw material viz. wood, bamboo, recycled fibre, bagasse, wheat straw, rice husk, etc.; approximately 35% are based on chemical pulp, 44% on recycled fibre and 21% on agro-residues. The geographical spread of the industry as well as market is mainly responsible for regional balance of production and consumption.

With added capacity of approximately 0.8 million tons during 2007-08 the operating capacity of the industry currently stands at 9.3 million tons. During this fiscal year, domestic production of

paper and paperboard is estimated to be 7.6 million tons. As per industry guesstimates, over all paper consumption (including newsprint) has now touched 8.86 million tons and per capita consumption is pegged at 8.3 kg.

Demand growth for paper has been hovering around 8% for some time. During the period 2002-07 while newsprint registered a growth of 13%, Writing & Printing, Containerboard, Carton board and others registered growth of 5%, 11%, 9% and 1% respectively. So far, the growth in paper industry has mirrored the growth in GDP and has grown on an average 6-7 per cent over the last few years. India is the fastest growing market for paper globally and it presents an exciting scenario; paper consumption is poised for a big leap forward in sync with the economic growth and is estimated to touch 13.95 million tons by 2015-16. The futuristic view is that growth in paper consumption would be in multiples of GDP and hence an increase in GDP by one unit would lead to increase in demand by more than one kg per capita. As per IPMA an estimate, paper production is likely to grow at a CAGR of 8.4% while paper consumption will grow at a CAGR of 9% till 2012-13. The import of pulp & paper products is likely to show a growing trend.

The average capacity of a paper mill in India is about 10,500 tonnes per annum (35 tonnes per day) compared to 85,000 tonnes per annum (260 tonnes per day) in Asia and 300,000 tonnes per annum (900 tonnes per day) in Europe and North America[7]. The Indian pulp and paper industry is highly fragmented, with top five producers accounting for only 25% of the total capacity. Several large integrated mills came on-stream during the late 1970s. The government policies in the 1980s and 1990s have led to the growth of a large number of small capacity mills using agro-waste as raw material.Large private industrial conglomerates typically own large paper companies that are financially well placed to implement new technologies. However, a considerably large number of Indian paper mills (generally, small paper mills) have not kept pace with technology improvement that has taken place elsewhere in the world. The industry has mainly adopted imported technology for the processing of indigenous raw materials.

As of now, according to the Planning Commission666 paper industries are engaged in the manufacturing of pulp, paper, and paperboards across the country. About 38% of the total paper production is based on recycled paper, 32% on wood, and the remaining 30% on agri-residue. Apart from the writing and printing paper, 77 mills with an installed capacity of 1.59

[7] TEDDY 2009

MT produce newsprint in India. Production of paper and paperboards in FY 2008 was 7.6 million tonnes. According to Indian Paper Manufacturing Association, the annual growth rate of the industry is expected to be 8.4%.

India is almost self-sufficient in the manufacture of most varieties of paper and paperboards. The country imports only certain speciality papers such as coated and cheque papers from Singapore, USA, UK, Japan, Germany, and Malaysia. Writing and printing grade paper, art paper, coated paper, and so on are exported to neighbouring countries like Sri Lanka, Bangladesh, Nepal, and Middle East countries.Muzzafarnagar is probably the most important cluster in Paper & Pulp Industry, which has been described below:

- **Muzzafarnagar Cluster:**

Muzaffarnagar is developing very fast in terms of business and small scale industries. Paper mills, Steel rolling mills & Sugar mills are major industries in the district. There are about 29 paper mills with 43 units installed though 2 mills shut down recently. Maximum paper mills are located at Bhopa road &Jansath road and the distance is about 8 to 10 km from the main city. The reason for setting up paper industry in particular area is availability of raw material. The units in the cluster are mostly large scale units, not falling under the SME category, as the investments in Plant & Machinery is more than Rs. 10 crores. Maximum units are functioning for nearly 15 to 20 years. Total installed capacity of this cluster is 1635 TPD with the capacity of individual plants ranging from 5 to 250 TPD. The major sub clusters are namely Bhopa Road (21 units, 1075 TPD), Jansad Road (9 units, 365 TPD), Shamli (6 Units, 120 TPD) and Other areas (7 units, 75 TPD).

Waste paper based, agro and waste paper based and 100% agro based units are installed in this cluster. Generally the units work round the clock & all are mechanized. The equipments used in this cluster are boilers, turbines, paper machines, pulper (slashing done), high consistency cleaners (separation of unwanted particles such as pins, leaves and stones), driers, etc. Major energy consuming equipments are boilers and driers. The total energy cost is 25 to 30% of the total production cost. Captive co-gen plants existin 11 units with cumulative capacity of 68.3 MW. The raw materials used are wheat straw, waste paper, bagasse, hessian, etc.

9.2 Pulp & Paper Manufacturing Process and Integration of SWHS

The Processes in the manufacturing of paper and paperboard can, in general terms, be divide into following steps:-

- Pulp making;
- Pulp processing;
- Paper/paper board production;
- Utilities and Waste treatment systems;

Salient Features of the processes:

- Paper and paperboard production processes are alike; involving digestion of a fibrous raw material except that in paper making mills are using recycled fiber.
- In case where wood and agro residues are used as raw material, chemical pulping actions release cellulose fibers by selectively destroying the chemical bonds in the glue-like substance (lignin) that binds the fibers together.
- After the fibers are separated and impurities are removed, the pulp is bleached to improve brightness and then processed by papermaking equipment
- Currently one-fifth of all pulp and paper mills practice process of bleaching. At the papermaking stage, the pulp can be combined with dyes, strength building resins, or texture adding filler materials, depending on its intended end use;
- The mixture is then de-watered, leaving the fibrous constituents and pulp additives on a wire or wire-mesh conveyor. Additional additives may be applied after the sheet-making step. The final paper product is usually spooled on large rolls for storage after series of presses and heated rollers;
- In case of recycled fiber, the raw material is slushed to deliberate it under shearing force and then the pulp is cleaned and used for paper making. For better quality of paper, deinking is done to remove the ink particles from the pulp. The major processes of paper making are mechanical, semi-mechanical and chemical and same is provided in the below table 9.1:

Table 9.1: Pulp Manufacturing Processes - A List

Process Category	Fiber Separation Method	Fiber Quality	Examples
Mechanical	Mechanical energy	Short, weak, unstable, impure fibers	Stone ground wood, refiner mechanical pulp
Semi-chemical	Combination of chemical and mechanical treatments	"Intermediate" pulp properties (some unique properties)	High-yield Kraft, high-yield sulfite.
Chemical	Chemicals and Heat	Long, strong, stable fibres	Kraft, sulfite, soda.
Defibration of wastepaper	Mechanical treatment of waste paper	Short fibers	RCF pulp.

The major process of pulp manufacturing for writing and printing paper is Kraft process and details of the sequences of manufacturing are shown in table 9.2 and Figure 9.1 below.

Table 9.2 Pulp Manufacturing Process Sequence:-

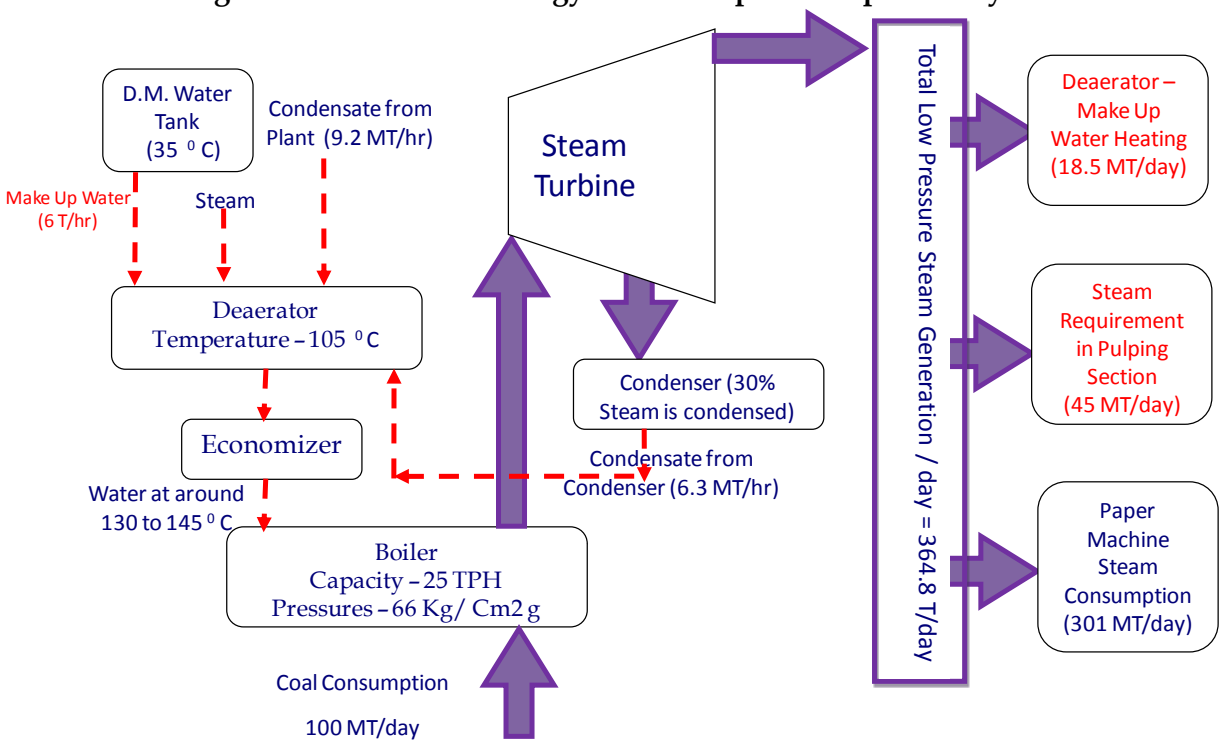
Process Sequence	Description
Fiber Furnish Preparation and Handling	Debarking, washing, chipping of wood logs and then screening of wood chips/secondary fibers (some pulp mills purchase chips and skip this)
Pulping	Chemical, Semi-Chemical, or mechanicalbreakdown of pulping material into fibers
Pulp Processing	Removal of pulp impurities, cleaning and thickening of pulp fiber mixture
Bleaching	Addition of chemicals in a staged process of reaction and washing increases whiteness and brighteness of pulp, if necessary
Stock Preparation and Paper Making	Mixing, refining and addition of wet additives to add strength, gloss, texture to paper product, if necessary paper making in paper machine.
Utilities and Waste treatment Systems	water treatment, steam and power generation and effluent treatment plant (ETP)

- Semi-chemical pulp is another grade of pulp, which is used for making corrugated containers. It involves partial digestion of raw material in a weak chemical solution followed by mechanical refining for fiber separation.
- Mechanically produced pulp is used for manufacture of newsprint as it is of low strength and quality.
- Recycled waste paper is one of the widely used raw materials for production of different quality of papers. It is processed to remove contaminants (adhesives, coatings, polystyrene foam, dense plastic chips, polyethylene films, etc) using a series of mechanical operations. Inks are removed by Floatation Technique using surfactants.
- The pulps from various processes are used to manufacture paper and boards of different qualities on different types of paper machines. The paper machines are used to mechanically and thermally dry the sheet of paper made from slurry of pulp.

The mechanical process is mainly used for wood based paper, where logs of wood are first shortened in length by cutting into pieces and then tumbled in large revolving drums to remove barks. Then the debarked logs are gouged out by mechanical drillers and sent to grinders along with hot water. Post grinding mixture of pulp and water prepared in the grinder is passed through vibrating screens to remove water. In chemical process cellulose fibre from the plant is removed by dissolving unwanted substances in chemical solution to decompose the plant and wash unwanted remain with water. Whereas in combined mechanical and chemical process chipped logs are cooked with steam and little caustic soda or sodium sulphite, followed by mechanical disintegration. The cooked pulp still contains some impurities, which have to be removed by washing the pulp in digesters and screening through the scraper to remove the washed pulp. Cleaning of pulp is followed by bleaching to make the pulp whiter.

Since the paper manufacturing is thermo mechanical process, paper manufacturing needs both thermal and electrical energy. Hence majority of paper industries have installed co-generation plants in order to meet their thermal as well as electrical energy requirement. A typical arrangements in paper industry to meet the thermal as well as electrical demand and energy balance is provided in figure 9.1 below:

Figure 9.1:Process and Energy Flow of Paper & Pulp Industry



Steam is generated in the coal fired boiler and fed to the Steam turbine (condensing back pressure turbine). Part of the steam is utilised for generation of the electricity and back pressure steam, which is at lower pressure, is utilised to fulfil the heating requirement of the manufacturing process. Approximately 30% of the high pressure superheated steam is utilised for the power generation and condensate from the condenser is returned back to the De-aerator tank. Low pressure steam is mainly utilised in paper machine and pulping section. Low pressure steam is also utilised in the De-aerator to heat the make-up water up to 105°C. Hot water at around 60°C is mainly required in the pulping section for the preparation of the pulp. Quantity of hot water required up to 80°C which is presently generated through utilisation of steam can be replaced through installation of SWH systems.

9.3 Realisable SWH Potential in Pulp & Paper Industry

Pulp and Paper Industry has mainly potential for direct SWH applications. As direct application, SWH can be used for the boiler make up water heating as well as to fulfil the hot water requirement in pulping section. However the quantity varies depending upon the boiler size and % condensate recovery. As far as in-direct SWH application in paper industry is concerned, scope is negligible. We visited ten pulp and paper industries located in Vapi

(Gujarat) and Muzaffarnagar (Uttar Pradesh) clusters to estimate the overall SWH potential. Based on the collected information, we have estimated the land requirement for installation of SWHS to realise the overall potential mainly for the abovementioned two applications. Information related to the land availability of particular industry also collected during the market assessment survey of that particular industry. Based on the same, maximum implementable SWH potential after considering the space constraint is assessed for those ten industries. We also collected data for fuels used in abovementioned ten industries. Data collected for processes and different types of fuel utilised in ten pulp and paper industries is provided in table 9.3 & 9.4 below respectively:

Table 9.3: Hot water requirement in Paper Industry and Land availability

Industry Name			Gayatrishakti Paper & Boards Limited	N.R. Agarwal Industries Limited (Unit - I)	N.R. Agarwal Industries Limited (Unit - II)	Ruby Macon Limited – Vapi	Shah Paper Mills Limited (Unit - III)	Bindal Paper Limited	Mahalaxmi Papers Limited	Shree Bhageshwari Paper Limited	TirupatiBalaji Fibers Limited	Daman Ganga Paper Mills Private Limited	Overall Parameters
Co-Generation Status			Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
Production (tonnes/ Annum)			84000	72000	33000	68985	43800	72000	25550	350	18000	20400	438085
Solar Potential For Boiler Feed Water Heating	T (0C)	Reqd	80	80	80	80	80	80	80	80	80	80	80
		Poss.	80	80	80	80	80	80	80	80	80	80	80
	HW Quantity (LPD)		168000	172800	144000	40320	81000	864000	72000	216000	36000	12000	1806120
Potential For Process Heating - Direct Hot water	T (oC)	Reqd		65	65		60						60-65
		Possi		65	65		60						60-65
	HW Quantity-LPD			400000	700000		704000						1804000
Solar Potential For Hot Air Generation	Quantity of HA (m3/hr)		15000	9500									24500
	T(0 C)	Reqd	140	140									140
		Poss.	80	80									80
	HW Quantity LPD		98079	62117									160195
Overall Swh Potential For Industries Surveyed			168000	572800	844000	40320	785000	864000	72000	216000	36000	12000	3610120
Estimated Land Requirement for SWH Installtion (Acres)			1.33	4.53	6.67	0.32	6.20	6.83	0.57	1.71	0.28	0.09	28.53
Land/Space Available for SWH installation			0.5	1	1	1.2	1	1.5	0.5	0.5	0.5	0.5	8.2
Maximum Implementable SWH Potential After Space Constraint	SWH Capacity (LPD)		63267	126533	126533	40320	126533	189799.5	63266.5	63266.5	36000	12000	847518
	% of Total Potential		37.7%	22.1%	15.0%	100.0%	16.1%	22.0%	87.9%	29.3%	100.0%	100.0%	23.48%

Table 9.4: Different Types of Fuels Used in Paper Industry

Industry Name		Gayatrishakti Paper & Boards Limited		N.R. Agarwal Industries Limited (Unit - I)		N.R. Agarwal Industries Limited (Unit - II)		Ruby Macon Limited - Vapi		Shah Paper Mills Limited (Unit - III)		Bindal Paper Limited		Mahalaxmi Papers Limited		Shree Bhageshwari Paper Limited		TirupatiBalaji Fibers Limited		Daman Ganga Paper Mills Private Limited		Overall Parameters	
Energy Utilised From Different energy Sources (Million kCal)	**Energy Source**	**Mk Cal**	**% of Total**	**Mk Cal**	**% of Total**	**Mk Cal**	**% of Total**	**Mk Cal**	**% of Total**	**Mk Cal**	**% of Total**	**Mk Cal**	**% of Total**	**Mk Cal**	**% of Total**	**Mk Cal**	**% of Total**	**Mk Cal**	**% of Total**	**Mk Cal**	**% of Total**	**MkCal**	**% of Total**
	Electricity	5,650	1.9 %	516	0.1 %	1238	0.7 %	12556	7.0 %	1413	0.9 %	9	0.0 %	4747	19.1%	0	0.0 %	9288	25.2%	5366	15.1%	40,783	1.8 %
	Indian Coal											604800	77.4%	20160	80.9%					30240	84.9%	655,200	28.9%
	Imported Coal	295,650	98.1%	354780	99.9%	167400	99.3%	167535	93.0%	78840	52.7%											1,064,205	46.9%
	FO																					-	0.0 %
	Bagasse																					-	0.0 %
	Wood											176400	22.6%					27594	74.8%			203,994	9.0 %
	Briquette /Rice Husk															234360	100.0%					234,360	10.3%
	LPG/Natural Gas									69350	46.4%											69,350	3.1 %
	LDO/HSD																					-	0.0 %
	Solar																					-	
	Total	**301300**	**100**	**355296**	**100**	**168638**	**100**	**180091**	**100**	**149603**	**100**	**781209**	**100**	**24907**	**100**	**234360**	**100**	**36882**	**100**	**35606**	**100**	2,267,892	**100 %**

Source: ABPS Infra Research & Analysis

From the table 9.3 & 9.4, it can be seen that pulp and paper industries in Vapi (Gujarat), have installed co-generation units to meet their thermal as well as electrical energy requirement. These utilise Indian as well as imported Coal for generation of super heated steam. Inspite of having their own co-generation units, these also draw significant amount of electricity from the electricity distribution company. Pulp and Paper Industries located in Muzaffarnagar cluster utilise rice husk, wood and natural gas for the generation of steam. We have estimated hot water requirement per day per tonne of paper produced based on the data collected from ten industries. We have analysed the data collected to generate different projection scenarios (realistic, optimistic and pessimistic) for the major hot water applications in the pulp and paper industries. Indian Paper Manufacturing Association has predicted around 8.4% growth rate for the pulp and paper industries for the period of next twelve years. We have considered the same growth rate and estimated maximum possible SWH penetration for the major hot water applications over the period of next twelve years. Maximum possible SWH penetration over the next twelve years under realistic scenario is presented in table 9.5 below:

Pulp & Paper Industry- SWH Potential Scenario		Realistic
All India Paper Production in FY 2007-08		7600000
Paper & Pulp Industry Growth Rate in India	%	8.40%
Hot water Requirement per day for Direct application per tonne of pa	LPD	8.6064
All India Annual Paper Production in Base Year FY 10	tonnes/	8930426
Overall Hot Water Requirement for Direct Applications in Paper Indu	LPD	76858421
Pulp & Paper Industry Growth Rate in India for the period FY 2011 to	%	8.40%

SWH Scenario For Paper & Pulp Industry			1	3	5	7	9	11	12
			FY11	FY13	FY15	FY17	FY19	FY21	FY22
All India Paper Production Capacity in MT	Year On Year	MT/Annur	9680581	11375225	13366527	15706417	18455920	21686739	23508426
All India Hot water requirement in Paper	Year On Year	LPD	83314528	97899236	115037085	135175017	158838214	186643797	202321876
All India Hot Water Requirement considering space constraints	**Year On Year**	**LPD**	**92995109**	**109274461**	**128403611**	**150881434**	**177294134**	**208330536**	**225830301**
Year Wise % SWH penetration in Realistic Scenario	**Year On Year**	%	0.68%	0.68%	0.68%	0.68%	0.68%	0.68%	0.68%
	Cumulative	%	0.68%	2.04%	3.40%	4.75%	6.11%	7.47%	8.15%
Maximum Achievable SWH Penetration in Realistic Scenario	**Year On Year**	LPD	127174	149437	175597	206336	242457	284900	308832
	Cumulative	LPD	127174	414469	752056	1148739	1614864	2162588	2471419
		M2	3093	10079	18288	27934	39269	52588	60098

Source: ABPS Infra Research & Analysis

We have also estimated overall realisable SWH potential for Pulp and Paper Industry in terms of LPD & Square Meter of the collector area required for next twelve years under realistic, optimistic and pessimistic scenarios and the same is presented in Table 9.6 below:

Table 9.6: SWH Potential Scenarios in Pulp and Paper Industry

		FY13	FY17	FY22
Realistic Scenario	LPD	414469	1148739	2471419
	M^2	10079	27934	60098
Optimistic Scenario	LPD	510119	1413833	3041747
	M^2	12405	34380	73967
Pessimistic Scenario	LPD	318822	883645	1901092
	M^2	7753	21488	46229

From the above table, it can be seen that cumulative overall realisable SWH market potential is 60098 square meter of the collector area in FY 2022 under the realistic scenario (most likely). We have also estimated state wise SWH potential in Pulp and Paper Industry by applying % of state wise paper manufacturing capacity to all India SWH potential under realistic scenario. Four States namely Gujarat, Maharashtra, Rajasthan and Uttar Pradesh offer around 60% of the overall realisable SWH potential for the pulp and paper sector in India. State wise realisable SWH market potential for the Pulp and Paper Industry in India is provided in overall Industrial SWH potential section.

10 SWH POTENTIAL IN CHEMICAL INDUSTRY

The chemical Industry is an important constituent of the Indian economy with an estimated turnover of around US$ 35 billion, constituting 1.5% of the global chemical industry of US$ 2400 billion. Increased competition resulting from globalization is driving the chemical industry towards consolidation, cost reduction, locations closer to raw materials, cheaper energy sources, low tax regimes, increased use of information technology and intensification of R&D activities. Enhanced worldwide concern for the protection of the environment has been forcing the industry to modernize and innovate.

10.1 Overview of Chemical Industry in India

The Chemical Industry includes basic chemicals and its products, petrochemicals, fertilizers, paints and varnishes, gases, soaps, perfumes and pharmaceuticals is one of the most diversified of all industrial sectors covering thousands of commercial products. It plays an important role in overall development of Indian economy. As per the Annual Report 2009-10 of Ministry of Chemicals and Fertilizers, Chemical Industry contributes about 3% in the GDP of the Country.

Chemical Industry is one of the oldest industries in India, which contributes significantly towards industrial and economic growth of the nation. It provides valuable chemicals for various end products such as textile, paper, paints, varnishes and leathers etc. that are required in almost all walks of life. The Indian Chemical Industry forms the backbone of the industrial and agricultural development of India and provides building blocks for downstream industries.

Though estimated size of the industry is around US$ 35 billion,thetotal investment in Indian Chemical Sector is approximately US$ 60 billion and total employment generated is about 1 million. The Indian Chemical sector accounts for 13-14% of total exports and 8-9% of total imports of the country. In terms of value, it is 12th largest in the World and 3rd largest in Asia. Over the last decade, the Indian Chemical industry has evolved from being a basic chemical producer to becoming an innovative industry. With investment in R&D, the industry is registering significant growth in the knowledge sector comprising of specialty chemicals, fine chemicals and pharmaceuticals. Gujarat dominates with 51% of the total share of major chemicals produced in the country followed by Maharashtra, Uttar Pradesh, Tamil Nadu and Punjab. Sub Working Group on Chemical Sector constituted for the 11thfive year plan has segmented Indian Chemical Industry into the following sub sectors:

- Chlor Alkali and Inorganic Chemicals
- Dyestuff and Dye Intermediates;
- Pesticides and Agrochemicals;
- Alcohol based industry;
- Organic Chemical Industry.

➢ **Chlor Alkali & Inorganic Chemical Sector:**

Chlor - alkali industry consists of caustic soda, chlorine and soda ash. These products are mainly used in paper, soap, detergents, PVC, medical, chlorinated paraffin wax, etc. Major inorganic chemicals are sulphuric acid, carbon black, titanium dioxide, calcium carbide, aluminium fluoride etc. The demand of Caustic Soda is driven by Aluminium industry. Chlorine is mainly consumed by PVC, medical, paper, chlorinated paraffin wax industries.

As per the Working Group Report on Chemical Sector for the 11th five year plan, the contribution of Chlor-Alkali & Inorganic Chemicals industry is to the extent of 8% of the total chemical industry. The total size of Indian Chlor Alkali & Inorganic Chemical industry is US$ 2500 million. The Chlor alkali and Soda Ash are the major inorganic chemicals accounting for 62% in this sector. Sulphuric Acid, Carbon Black, Titanium Dioxide are other major contributors. Production of Alkaline Chemicals has increased from 5070000 MT to 5442000 MT during the period of 2003-04 to 2008-09, whereas production of other inorganic chemicals has increased from 441000 to 513000 MT during the same period.

➢ **Dyestuff and Dye Intermediates:**

Dyestuff industry plays an important role in the economic development of the country. The Indian Dyestuff Industry, which was primarily started to cater to the needs of domestic textile industry, now not only meets more than 95% requirement of the domestic market, but has gradually also made a dent in the global market. Today, India exports dyes and dye intermediate to the very same countries, on which it was dependant till a decade ago. All ranges of dyes such as disperse, reactive, vats, pigments and leather dyes are now being

manufactured in India. This industry is based on chemicals derived from coal tar and the petrochemical industry. This industry forms an important link in the chain of other chemical industry such as textiles, leather, plastic, paper, packaging, printing inks, paints and polymers etc. The textile industry is the major consumer of dyestuffs and about 70% of the total production is consumed by this sector.

The basic raw materials used for the manufacture of dyestuff are Benzene, Toluene, Xylene and Naphthalene (BTXN). These raw materials are initially transformed into dye intermediates by nitration, sulphonation, amination, reduction and other chemical unit process. Further, the formulation and reaction of the intermediates viz. diazotition and coupling of the intermediates are carried out for the manufacture of a particular dyestuff. Production of dyestuff has increased from 26000 MT in the FY 2003-04 to 32000 MT in the year 2008-09. Two Western States viz Maharashtra and Gujarat account for over 90% of the dyestuff production in the country.

- **Pesticides and Agrochemicals:**

India is a densely populated country with about 15% of the world population and 2.5% of the world geographical area. About 40% of the area is available for cultivation. India's population, at present, is over 1,000 million. India is predominantly an agricultural country. The total food grain production has risen from 50.82 million MT in 1950-51 to an estimated 209.32 million MT in 2005-2006. In order to meet the needs of a growing population, agricultural production and protection technology have to play a crucial role. Substantial food production is lost due to insect pests, plant pathogens, weeds, rodents, birds, nematodes and in storage.

The Indian Pesticides Industry can be broadly divided into three categories, Multi-National Companies, Indian companies including the Public Sector companies and Small Scale Sector Units. Besides about 60 Indian companies in the organized sector manufacturing pesticides, there are around 10 multi-national companies operating in the country. Most Indian manufacturers are focused on off-patent pesticides, which comprise over 70% of the Indian market. Production of pesticides during the period of 2003-04 to 2008-09 has almost remained constant.

- **Alcohol based Chemical Industry:**

Alcohol based chemical industry occupies an important place in the Indian Chemical Industry. Industrial alcohol in India is based on sugarcane molasses. There was a time when molasses were wasted and sugar industries were finding it difficult to dispose molasses. Several committees appointed by Government of India examined the issue and concluded that the most value added use of alcohol is production of chemicals and recommended setting up of alcohol based chemical units across the country. Development of alcohol based chemical industries has helped proper utilization of molasses in the production of alcohol.Alcohol has two major uses:

(i) Drinking by diluting and blending etc.

(ii) Industrial use for production of various chemicals like Acetic Acid, Acetic Anhydride, Ethyl Acetate, Acetone, MEG, etc.

These alcohol based chemicals provide feedstock for a variety of industries such as synthetic fibres, pesticides, pharmaceuticals, paints, Dyestuffs, adhesives, etc. Alcohol is now also used for blending with motor spirit. There are about 300 distilleries with installed capacity of approx. 32,000 lakh litres. However, the capacity utilization is only about 55% with present production of approx. 17,000 lakh litres. There are about 20 major units engaged in the manufacturer of alcohol based chemicals. The three largest users of alcohol are M/s. Jubilant Organosys Ltd., M/s. India Glycol Ltd. and M/s. Reliance Industries Ltd. These three companies account for 62% of the total requirement of industrial alcohol by the alcohol based chemical industries.

- **Organic Chemical Industry:**

The basic organic chemicals and intermediates industry is one of the important sectors of the Chemical Industry and has made phenomenal progress since independence. This sector has played a very important role in the overall development of other sectors of the Chemical Industry like drugs and pharmaceuticals, dye stuffs and dye intermediates, leather chemicals, paints, pesticides, etc. With the substantial growth in the exports of the above commodities in recent years, the basic organic chemicals and intermediate industry is expected to have higher growth rate during the 11th plan period.The major organic chemicals are Acetic Acid, Acetic Anhydride, Acetone, Phenol, Methanol, Formaldehyde, Nitro Benzene, Citric Acid, Maleicanhydride, Pentaerythrytol, Aniline, Acetaldehyde, Ethanolamine, Ethyl Acetate, etc.,

The actual production of select major chemicals during the period 2003-04 to 2008-09 and up to December 2009 for the year 2009-10 is provided in the below table 10.1:

Table 10.1 : Year Wise Production of Major Chemicals in India

(Figures in '000 MT)

Years	Alkali Chemicals	Other Inorganic Chemicals	Organic Chemicals	Pesticides and Insecticides	Dyes and Dyes Stuff	Total Major Chemicals
2003-04	5070	441	1474	85	26	7096
2004-05	5272	508	1506	94	28	7408
2005-06	5475	544	1545	82	30	7676
2006-07	5269	602	1545	85	33	7543
2007-08	5443	609	1552	83	44	7731
2008-09	5442	513	1254	85	32	7326
2009-10 (Upto December 2009)	4133	382	920	58	30	5523

Source: Annual Report 2009-10 , Ministry of Chemicals &Fertilizer, Department of Chemicals and Petrochemicals

Indian Chemical Industry is also responding to the increased environment consciousness worldwide. Cost reduction is being aggressively attempted through improved operating norms. Over the last decade, the Indian Chemical Industry has evolved from being a basic chemical producer to becoming an innovative industry. As discussed earlier, Gujarat dominates with 51% of the total share of major chemicals produced in the country followed by Maharashtra, Uttar Pradesh, Tamil Nadu and Punjab. We have provided below brief overview of two major clusters in Gujarat:

Vapi Cluster:

Vapi Industrial Estate, developed by Gujarat Industrial Development Corporation. The Estate, developed in phases (1 to 4). About 70% of the Industries are chemical & Chemical related such as Dyes & Dyes intermediates, Pigments, Pesticides, Fine Chemicals and Pharmaceuticals etc.There are nearly 600 units spread across this cluster. Maximum units are functioning for lastt12 -15 years, since majority of the units are engaged in organic, inorganic, fine chemicals, pigments used by the polymer processing, the pharmaceutical companies, textile chemicals etc. The processes vary for dyes, pigments as well as chemicals in terms of equipments used. The pigments manufacturing units have a capacity of 5 to 6 tpd. Majority of the units are having an

LT connection. Major Raw materialsareCaustic Soda, Soda Ash, Hydroflamic Acid, PotasiumSulphate, Sulphuric Acid, Solvent, Calcium Carbonate, Carbon Black, Nitric Acid, Sodium Hypochlorite, Acetic Acid, Sodium Hexumeta, Phosphate, Magnesium Chloride, Sodium, etc.

Electricity is supplied by local distribution company through five 66kV gridsubstations. Gas is supplied by Gujarat State Petroleum Corporation Ltd. (GSPC). At present, gas availability is an issue. Other fuels such as FO/ LDO/Coal/ Wood are available from local traders. Due to cheap cost, large number of units are using wood as a fuel.

Ahmedabad Cluster:

Ahmedabad plays a vital role in rendering the commercial resources and market access for the economies of neighbouring cities. Some major industries of Ahmedabad are Textiles, Chemicals, and Pharmaceuticals & Petrochemicals. The main areas where the chemical industries are located are spread across Vatwa – Ph-1 to Ph-4, Odhav industrial area &Naroda Industrial area. Some small units have also come up in Dudheshwar. There are approximately 600 units in this cluster who are engaged in manufacture of various types of dyes & chemicals, pigments.InVatva approx 300 units, in Odhav 50 to 60 units, and in Naroda 30 to 40 units are functioning. Finished products are General Chemical, Dyes & Dyes Intermediates, Fine Chemicals, Food Chemicals & Foundry chemicals. Large number of units arein business for more than 15 years & are operating in general shift or in 2 shifts.

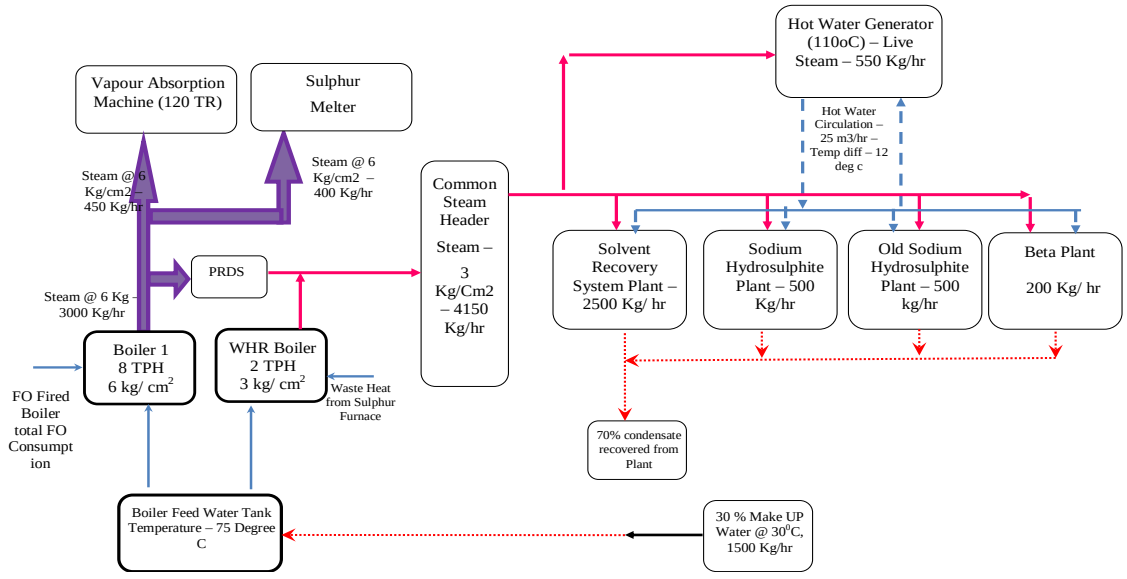
The units spread across Vatwa&Odhav are largely into Reactive Dyes, Disperse Dyes, Acid Dyes, Solvent dyes, as well as different Pigments – Reactive Blue, Red, Yellow of different grades. Some units are also into agro chemicals - technical grade as well as formulations. The major concern / issue is the pollutants being created due to the chemical reactions as well as effluent being generated round the clock from over 300 units.

Some of the equipments, which are in use namely, Vessels, Spray Dryer (capacity up to 1000 ltr/hr.), Reverse osmosis system Dryer, Magnet Vibrator, Mixer, Boiler, Ball mill/Blinder, Filter press. Electricity is supplied by Torrent, and is available for 24 hours. Besides this, these are using Coal/Wood/LDO, available from local traders.

10.2 Chemical Industry Process and Integration of SWHS

Manufacturing of chemicals involves many diverse processes to produce a wide variety of end products, including various degrees of purity and concentrations for each one. Also, manufacturing processes of these chemicals vary significantly. However, some of the major chemical processes involved are evaporation, crystallization, centrifuging, drying, distillation and packaging etc. It is difficult to prepare the generic flow diagram for the chemical industry; however typical process flow diagram for one of the industry visited by us for the primary data collection purpose is shown in Figure 10.1 below:

Figure 10.1: Process and Energy Flow of Chemical Industry



Typical chemical industry requires all types of utilities such as steam, hot water, compressed air, chilled water for process chilling, cooling water and hot air for the manufacturing of the different types of chemicals. In Chemical Industry, hot water is required for both direct as well as indirect applications. Typically, Steam is generated in the boiler and the same is utilised to cater various heating requirements of the process. Condensate is recovered and the same is fed back into the boiler feed water tank. Many chemical industry units have also installed

economiser to increase the feed water temperature. Quantity of the makeup water requirement varies from industry to industry based on the percentage of the condensate recovery. It is possible to heat make up water using SWHSandreduce fuel consumption in the boiler.

Typical Chemical Industry also requires chilled water at different temperature ranges. In order to fulfil chilled water requirement, either Vapour Compression Machine or Vapour Absorption Machine is installed. Most of the chemical industries have installed dryers to reduce the moisture content in the final product. Hot air is mostly generated by means of steam generated in the boiler and electrical heaters. It is also possible to generate hot air up to 80°C through installation of SWH system.

10.3 Realisable SWH Potential in Chemical Industry

In Chemical Industry, direct SWH application is to heat the quantity of makeup water required in the boiler for the generation of steam. However, the quantity of the make-up water varies depending upon the boiler size and percentage of the condensate being recovered. In addition, there is a large scope for indirect SWH application in the chemical industry for drying and process cooling purpose. We visited five chemical industries located in Vadodara cluster located in the State of Gujarat for the purpose of primary data collection. Based on the collected information, we have assessed the maximum realisable SWH potential in abovementioned chemical industries considering various constraints. Primary data as well as different types of fuels being used by the five chemical industries collected through primary survey and the same is provided in the table 10.2 and 10.3 respectively:

Table 10.2: Hot water requirement in Chemical Industry and Land availability

Industry Name			Paushak Limited	Shimalin Chemicals & Industries Private Limited	Sud Chemie India Private Limited	Transpek Silox Industries Private Limited	United Phosphorous Limited	Overall Parameters
Co-Generation Status			No	No	No	No	No	
Production (tonnes/ Annum)			1000	106350	6600	9000	1500	124450
Solar Potential For Boiler Feed Water Heating	Temp (0C)	Required	80	80	80	80	80	80
		Possible	80	80	80	80	80	80
	Hot Water Quantity (LPD)		43200	18000	24000	36000	7000	128200
Solar Potential For Process Heating (Direct Hot water Application)	Temp (0C)	Required			80			80
		Possible			80			80
	Hot Water Quantity (LPD)				72000			72000
Solar Potential For Hot Air Generation	Quantity of HOT Air (m3/hr)		2111	59834	0	25327	5994	93265
	Temp (0C)	Required	80	110	0	80	80	80-110
		Possible	80	80	0	80	80	80
	Hot Water Quantity (LPD)		13800	Not Considered	0	165600	39192	218592
Overall Swh Potential For Industries Surveyed			57000	18000	96000	201600	46192	418792
Estimated Land Requirement for SWH Installtion (Acres)			0.45	0.14	0.76	1.59	0.37	3.31
Land Available for SWH installation			0.3	0.1	0.35	0.55	0.2	1.5
Maximum Implementable SWH Potential After considering	SWH Capacity (LPD)		37960	12653.3	44286.55	69593.15	25306.6	189799.5
	% of Total Potential		66.6%	70.3%	46.1%	34.5%	54.8%	45.32%

Source: ABPS Infra Research & Analysis

Table 10.3: Different Types of Fuels Used in Chemical Industry

Industry Name		Paushak Limited		Shimalin Chemicals & Industries Private Limited		Sud Chemie India Private Limited		Transpek Silox Industries Private Limited		United Phosphorous Limited		Overall Parameters	
Energy Utilised From Different energy Sources (Million kCal)	Energy Source	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total
	Electricity	3,096	27.8%	3406	65.9%	3901	14.9%	6192	32.2%	1806	9.7%	18,400	22.9%
	Indian Coal											-	0.0%
	Imported Coal											-	0.0%
	FO			1764	34.1%			13063	67.8%			14,827	18.4%
	Bagasse											-	0.0%
	Wood											-	0.0%
	Briquette	8,030	72.2%							16800	90.3%	24,830	30.9%
	Natural Gas					22350	85.1%					22,350	27.8%
	LDO/HSD											-	0.0%
	Solar											-	
	Total	11126	100%	5170	100%	26250	100%	19255	100%	18606	100%	80,407	100%

Source: ABPS Infra Research & Analysis

Analysis of the table 10.3 shows that electricity, furnace oil and briquettes are being used by the chemical industries to meet their thermal and electrical energy requirement. During market assessment survey, it was observed that a couple of chemical industries have also converted their Furnace Oil fired boiler to the briquette fired one to reduce their steam cost. One of the Chemical Industries also utilized the waste gas generated as a by-product from the processes in order to generate steam and reduce the quantity of furnace oil required. We have estimated hot water requirement per day per tonnes of chemical production from the data collected from five chemical industries. We have analysed the data to generate different projection scenarios for major hot water applications. Ministry of Chemicals and Fertilisers has predicted growth rate of around 10% for the Chemical sector for the next five years. We have considered the same growth rate in order to estimate maximum possible SWH penetration for major hot water applications over the period of next twelve years. Maximum possible SWH penetration over the next twelve years under realistic scenario is provided in table 10.4 below:

Chemical Industry- SWH Potential Scenario		Realistic
All India production of major chemicals in year 2008-09	MT	7326000
Chemical Industry Growth Rate in India the year 2009-10	%	10.00%
Average Hot water Requirement per day for Direct application per tonnes of Chemical production	LPD	3.37
Annual Prduction of Chemicals in Base Year FY 10	MT	8058600
Overall Hot Water Requirement for Direct Applications in Chemical Industry	LPD	27118338
Chemical Industry Growth Rate in Inddia during 2011 to 2022	%	11.00%

SWH Scenario For Chemical Industry			1	3	5	7	9	11	12
			FY11	FY 13	FY15	FY17	FY19	FY21	FY22
ALL India production of major chemicals	Year On Year	MT/annum	8945046	11021191	13579210	16730944	20614196	25398751	28192614
All India Hot Water Requirement in	Year On Year	LPD	30101356	37087880	45695977	56302014	69369711	85470421	94872167
All India Hot Water Requirement considering space constraints	Year On Year	LPD	39046402	48109071	59275187	73032958	89983907	110869172	123064781
Year Wise % SWH penetration in Realistic Scenario	Year On Year	%	1.59%	1.59%	1.59%	1.59%	1.59%	1.59%	1.59%
	Cumulative	%	1.59%	4.78%	7.97%	11.16%	14.35%	17.53%	19.13%
Maximum Achievable SWH Penetration in Realistic Scenario	Year On Year	LPD	217466	267940	330129	406752	501159	617477	685400
	Cumulative	LPD	217466	726793	1354335	2127529	3080182	4253945	4939345
		M2	5288	17674	32934	51736	74901	103444	120111

Source: ABPS Infra Research & Analysis

Estimation of overall realisable SWH potential for Chemical Industries has also been carried out in terms of LPD and Square Meter of the collector area required for the next twelve years under three different scenarios and the same is presented in Table 10.5 below:

Table 10.5: SWH Potential Scenarios in Chemical Industry

		FY13	FY17	FY22
Realistic Scenario	LPD	726793	2127529	4939345
	M^2	17674	51736	120111
Optimisti Scenario	LPD	894514	2618497	6079194
	M^2	21752	63675	147829
Pessimistic Scenario	LPD	559072	1636561	3799496
	M^2	13595	39797	92393

Cumulative realisable SWH potential for the Chemical Industries under realistic scenario will be around 120111 Square Meter in the year FY 2022. State wise SWH potential in Chemical Industries is estimated by applying % of state wise chemical production to the all India SWH potential under realistic scenario. State wise realisable SWH potential in the Chemical Industry is provided in overall Industrial SWH potential section.

11 SWH POTENTIAL IN AUTO COMPONENT INDUSTRY

11.1 Auto Component Industry including Electroplating

The Indian auto component industry is one of the India's sunrise industries with tremendous growth prospects. From a low key supplier of components to the domestic market alone, the industry has emerged as one of the key auto component centers in Asia and is today seen as a significant player in the global automotive supply chain. India is now a supplier of a range of high – value and critical automobile components to global automakers such as General Motors, Toyota, Ford and Volkswagen, many others.

Indian Auto Component Industry has gained reputation worldwide by becoming compliant in global automotive standards. According to estimates available from the Automotive Component Manufacturers Associations of India (ACMA), the global automotive component industry is estimated to be more than US $ 1 trillion. It is forecasted to hit US $ 1.9 trillion by 2015. Out of total auto component market in 2015, around 40%, US $ 700 billion market is expected to be driven by low cost countries globally. India is one of the fastest growing low cost manufacturers of auto components in the world. Theauto-componentmarket is estimated to be US$ 19 billion in 2008-09 in India, of which US$ 3.8 billion is the export market. With the growth in auto mobile sector, entry of new players in India, rising income and export, auto component manufacturers in India have potential to rise at a CAGR of 13% to touch US $ 40 billion by 2015. In volume terms, two/three wheelers are the largest customers segment of auto-component market (around 34%), followed by passenger cars with 33% share and commercial vehicle contributing 24% of the market. Statistics of Indian Auto Component Industries for last six years is presented in table 11.1 below:

Table 11.1 : Auto Component Industry Statistics (Value in US $ Billions)

Description	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
Turnover	8.7	12	15	18	18.4	22
Export	1.69	2.47	2.67	3.52	3.8	3.8
Import	1.9	2.48	3.6	5.22	6.8	8.16
Investment	3.7	4.4	5.4	7.2	7.3	9
Imports as percentage of Turnover	22	21	24	29	37	37
Exports as percentage of Turnover	20	21	18	20	21	13

Source: ACMA

Auto component industry is broadly classified into the engine and engine parts, transmission and steering parts, suspension and breaking parts, equipments, electrical parts and others.Out of these engine and engine parts comprise the largest product segment of the auto component industry with 31% share.Out of 6400 players present in the Indian market, only 600 constitute the organised sector and contribute more than 77 percent of the country's total production of the auto components. Large Indian players contribute about 43 percent of the total production, while foreign companies contribute about 15 percent.

The industry is located in certain clusters in the north, south and western parts of the country with only a few units in the eastern region. As per ACMA, out of 600 auto component industries in the organized sector, 243 and 186 units are located in Northern and Western Region respectively whereas, Only 37 units are located In Eastern Region. Tamil Nadu alone contributes over 20% of the total Indian output. The units in Tamil Nadu, in anticipation of the entry of new car manufacturers, went on expanding their capacities. Even new units came up, fuelled mainly by the expectation of vehicle manufacturers setting up associated units. While Ford was in the forefront, Hyundai and Hindustan Motors took the same course. We have provided brief overview of couple of major auto component clusters below:

- **Chennai Cluster:**

Chennai auto cluster in Tamil Nadu is one of the fast growing and the most successful clusters in India. It is at the forefront of the auto motive and auto ancillary sectors, and has earned a reputation for its industrial culture. Over 100 large companies in the auto and ancillary industry are based in the State, maintaining highest production norms by implementing internationally recognized quality standards such as TPM and TQM. Chennai has been the destination of choice by international automotive giants such as Ford, Mitsubishi motors, Hyundai, Visteon etc. and home to the internationally acclaimed TVS Group, Range Group, Ashok Leyland, etc. which started their business in Chennai, before becoming the world leaders in their own fields.

Presently, it hosts more than 100 key players in the auto component industry. However, it is found that there exists many firms in the cluster which are small; essentially Tier 2 or Tier 3 suppliers, and replacements and small job shops. Some of the major component manufacturers in the cluster are Autolec industries, Axles India Ltd., Brakes India Ltd., Engine Valves Ltd., and Tube Investments India Ltd., etc. Chennai has two distinct auto clusters located at Maraimalai Nagar and Sriperembudur. Maraimalai Nagar is located at 40 Km from Chennai city on the national highway and is well connected by both road and rail transport and has easy access to

the Chennai International Airport and Seaport, where Mahindra World City, Ford India and large number of automotive ancillary units are located. Sriperembudur is located 45 km away from Chennai on another national highway (Bangalore highway). Here, Hyundai Motors India has large number of auto and ancillary units.

- **Delhi / Gurgaon Auto Cluster:**

The Gurgaon Auto Cluster came into being as a result of the initiative of the MarutiUdyog Limited (MUL) to set up a plant in 1983 at Gurgaon to manufacture fuel efficientlow cost passenger cars for masses. MUL switched rapidly from reliance on imported components to sourcing from local vendors to ensure that quality standards were met within reasonable cost parameters. This was a strategy that contributed to the emergence of Indian component industry over a period of 20 years.

11.2 Auto Component Industry Process and Integration of SWHS

Manufacturing of auto components involves many steps such as casting, forging, painting and electroplating etc. Original Equipment Manufacturers and larger players have in house facility to perform abovementioned activities. However, some industries outsource the activities such as electroplating and painting of the auto components to smaller and unorganised sector units. Based on the interaction with the industrial experts as well as preliminary visits, we attempted to identify potential areas where hot water is requirement for direct as well as indirect heating applications for both types of industries. Based on the interaction, we understand that hot water requirement in auto component industries involved in the casting and forging related activities is almost nil. However, industries involved in the electroplating of the various auto components require hot water/steam for the heating of electrolyte solution. An auto component industry with in house paint shop also requires hot water and steam for heating application. We have explained the major steps involved in electroplating process below:

Electroplating Industry Process

Electroplating is one of the several techniques of metal finishing. It is a technique of deposition of a fine layer of one metal on another through electrolytic process to impart various properties and attributes, such as corrosion protection, enhanced surface hardness, luster, colour, aesthetics, value addition etc. Electroplating is either performed as a part of manufacturing process by large scale manufacturing plants (e.g. automobile, cycle, engineering) or performed as a job-work for a wide variety of components by small and tiny units, the market share of the latter being far more than the former. These units are spread across the entire country with

significant concentration in severalstates like Punjab, Haryana, part of Uttar Pradesh, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu and West Bengal. Various steps involved in electroplating are soak cleaning, acid pickling, anodic cleaning, pre dip, neutralize dip, zinc electroplating, trivalent passivation and oven drying etc.

Electroplating Industry is widely spread out across the country. As mentioned earlier, there are primarily two types of units:

- Primary Users and Original Equipment Manufacturers (OEM), who do electroplating as one of their overall manufacturing activity; and
- Job Work Unit who do only plating for a larger variety of components for both domestic and export purpose;

Certain states have large number of units concentrated in some towns/cities. Though, it is difficult to find out the distribution of production between the organized and small scale unorganized sector, it is perceived that latter holds significantly large share of the market.

11.3 Realisable SWH Potential in Auto Component Industry

We selected two clusters of auto component industries located in Pune and Coimbatore for collection of primary information and to estimate the overall and realisable market potential for SWH systems. We visited ten auto component industries located in these two clusters. Based on the interaction with the industrial experts, we identified different steps involved (e.g. casting, forging) in the manufacturing of the auto components. At the same time, we also tried to identify potential areas where hot water is required for both direct and indirect applications. Based on the interaction, we understand that hot water requirement in Auto component industries involved in the casting and forging related activities is almost nil. However, industries involved in the electroplating of the various auto components require hot water/steam for heating of the electrolyte solutions.

In order to estimate realizable SWH potential from Auto component Industries involved in electroplating and painting related activity, we further visited four industries located in the Gurgaon&Manesar clusters. Based on the interaction with the industrial experts, we tried to understand the different steps involved in the electroplating process. At the same time, we also tried to identify potential areas where hot water is required for direct as well as indirect applications. It is noted that basic electroplating consists of:

- A plating bath filled with water containing a small amount of acid or alkali added to improve its conductivity. Thus baths used for plating are either acidic or alkaline bath;
- An anode (positive electrode) – either the plating metal or an inert electrode: this is expended as the process goes on and replenished periodically;
- A Cathode (negative electrode) – the item to be plated: these can be either hung inside the bath or placed in a barrel, which is rotated slowly to ensure even deposition of the plating material;

Based on the analysis of the data collected from the four electroplating industries, we understand that steam/electrical heater is utilised to generate the required temperature of the electrolyte solution. The same can also be achieved by utilisation of hot water generated through installation of solar water heating systems. However, integration of the SWH system with the existing process is a major issue. Also, in unorganised sector, availability of the space is a major issue. As mentioned earlier, certain states have large number of units concentrated in some town/cities. The production data of organised and unorganised sectors situated in different States is not available. Hence, assessment of potential for integration of SWH system has been carried out based on the number of units installed in each region. Primary process related data as well as that for different types of fuels being used by seven auto component industries collected through primary survey is presented in table 11.2 and 11.3 respectively:

Table 11.2: Hot Water Requirement and Land Availability in Auto Component Industries

Industry Name			Minda Cor. Ltd	Bosch Ind P. Ltd	Minda Co. Die Cas	ACME Industries	Jay Bharat Maruti	Omex Auto	Speedo Max	Overall Parameters
Co-Generation Status			No	No	No	No	No	No	No	
Industry No			1	2	3	4	5	6	7	7
Solar Potential For Boiler Feed Water Heating	Temp (0C)	Required	55	70	0	0	80	80	80	80
		Possible	80	80	0	0	80	80	80	80
	Hot Water Quantity (LPD)		5760	4500	0	0	27000	75000	10000	122260
Solar Potential For Process Heating (Direct Hot water Application)	Temp (0C)	Required	80	80	0	0	0	0	80	80 - 110
		Possible	80	80	0	0	0	0	80	80
	Hot Water Quantity (LPD)		5760	2800	0	0	0	0	36000	44560
Overall Swh Potential For Industries Surveyed			11520	7300	0	0	27000	75000	46000	166820
Estimated Land Requirement for SWH Installtion (Acres)			0.09	0.06	0.00	0.00	0.21	0.59	0.36	1.32
Land Available for SWH installation			0.1	0.1			0.12	0.3	0.15	0.77
Maximum Implementable SWH Potential	SWH Capacity (LPD)		11520	7300	0	0	15184	37960	18980	90944
After considering Space Constraint	% of Total Potential		100.0%	100.0%	0.0%	0.0%	56.2%	50.6%	41.3%	54.52%

Source: ABPS Infra Research & Analysis

Table 11.3: Different Types of Fuels Used in Auto Component Industries

Industry Name		Minda Cor. Ltd		Bosch Ind P. Ltd		Minda Co. Die Cas		ACME Industries		Jay Bharat Maruti		Omex Auto		Speedo Max		Overall Parameters	
Energy Utilised From Different energy Sources (Million kCal)	Energy Source	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total	MkCal	% of Total
	Electricity	730	39.0%	6192	81.8%	4602	100.0%	138	100.0%	361.2	37.0%	412.8	1.1%	95	2.0%	12,532	21.4%
	Indian Coal															-	0.0%
	Imported Coal															-	0.0%
	FO															-	0.0%
	Bagasse															-	0.0%
	Wood															-	0.0%
	Briquette/Rice Husk															-	0.0%
	LPG	896								615.6	63.0%	38142.5	98.9%	4704	98.0%	44,358	75.8%
	LDO/HSD	245	13.1%	1382	18.2%		0.0%									1,627	2.8%
	Solar															-	
	Total	1871	100%	7574	100%	4602	100%	138	100%	977	100%	38555	100%	4799	100%	58,517	100%

Source: ABPS Infra Research & Analysis

Analysis of the table 11.3 shows that electricity and LPG are being used by the Auto Component Industries involved in electroplating and painting related activities to meet their thermal and electrical energy requirement. During market assessment survey, it was observed that a couple of auto component industries are also using HSD & LDO to meet their thermal energy requirement. Auto Component industries manufactures wide variety of auto components of different sizes and different qualities. Production data of the various auto component industries at national level and that at States level is not available; hence we have done assessment of potential for integration of SWH system based on the number of units installed in four major regions. We have estimated hot water requirement per day per unit of auto component industries based on the data collected from seven auto component industries. We have also considered growth rate of 3% for auto component industries for the next twelve years to estimate maximum possible SWH potential for major hot water applications. Maximum possible SWH penetration over the next twelve years under realistic scenario is provided in table 11.4 below:

Autocomponent Industry- SWH Potential Scenario		Realistic
Number of Autocomponent Industry in India in Base Year FY 10	No.	603
Average Hot water Requirement per day for Direct application For Autocomponenet Industry	LPD	23831
Overall Hot Water Requirement for Direct Applications in Autocomponent Industry	LPD	14370351
Increase in number of Autocomponent Industry during 2011-2022	%	**3.00%**

SWH Scenario For Autocomponent Industry			1	3	5	7	9	10	11	12
			FY11	FY13	FY15	FY17	FY19	FY20	FY21	FY22
All India Number of Installed Autocomponent Industry	Year On Year	No	621	659	699	742	787	810	835	860
All India Hot water requirement in Autocomponent	Year On Year	LPD	14801462	15702871	16659176	17673720	18750049	19312551	19891927	20488685
All India Hot Water Requirement considering space	Year On Year	LPD	8069184	8560598	9081938	9635028	10221801	10528455	10844309	11169638
Year Wise % SWH penetration in Realistic Scenario	Year On Year	%	1.62%	1.62%	1.62%	1.62%	1.62%	1.62%	1.62%	1.62%
	Cumulative	%	1.62%	4.87%	8.12%	11.37%	14.62%	16.25%	17.87%	19.50%
Maximum Achievable SWH Penetration in Realistic Scenario	Year On Year	LPD	131113	405257	696096	422715	750057	921129	1097334	1278825
	Cumulative	LPD	131113	802528	2047151	3317957	4651981	5573110	6670444	7949268
		M2	3188	19515	49781	80683	113123	135522	162207	193304

Source: ABPS Infra Research & Analysis

Estimation of overall realisable SWH potential for Auto Component Industries has also been carried out in terms of LPD and Square Meter of the collector area required for the next twelve years under three different scenarios and the same is presented in Table 11.5 below:

Table 11.5: SWH Potential Scenarios in Auto Component Industry

		FY13	FY17	FY22
Realistic Scenario	LPD	802528	331795	7949268
	M^2	19515	80683	193304
Optimistic Scenario	LPD	987727	408364	9783715
	M^2	24019	99303	237913
Pessimistic Scenario	LPD	617330	2552275	6114822
	M^2	15012	62064	148695

Cumulative realisable SWH potential for the Auto Component Industries under realistic scenario is around 193304 Square Meter in year FY 2022. Region wise SWH potential in Auto Component Industries is estimated by applying % of units installed in different regions under realistic scenario. Region wise realisable SWH potential in the Auto Component Industries is provided in overall Industrial SWH potential section.

12 OVERALL POTENTIAL FOR SWHS IN INDUSTRIAL SECTORS

12.1 Overall Realisable SWHS Potential in Industrial Sectors

Overall realisable SWH potential for all the Industrial Segments studied in the Report i.e. Food Processing Industry (Dairy, Sea food Processing, Beer and Sugar), Pulp & Paper Industry, Pharmaceutical Industry, Chemical Industry, Textile Processing Industry, Auto Component Industry and Rice Processing Industry, is around 2089758, 1731656 and 133358 square meter by FY 2022 in optimistic, realistic and pessimistic scenarios respectively. Overall realisable SWH potential for all the Industrial Segments in three different scenarios is presented in below table:

Select Scenario		Optimistic			Realistic			Pessimistic		
Industry Segment		FY13	FY17	FY22	FY13	FY17	FY22	FY13	FY17	FY22
Dairy	LPD	**1745044**	4253056	8036295	1625194	4133206	7916446	1505345	4013357	7796597
	m²	42434.6	103422.4	195420.2	39520.18	100508	192505.8	36605.78	97593.61	189591.4
Paper & Pulp	LPD	510115	1413833	3041747	414468.7	1148739	2471419	318822.1	883645.4	1901092
	m²	12405	34380.45	73966.77	10078.72	27934.12	60098	7752.861	21487.78	46229.23
Textile Processing	LPD	3994883	11450192	25808974	3245842	9303281	20969791	2496802	7156370	16130609
	m²	97144	278436.6	627602	78929.79	226229.7	509926.6	60715.23	174022.9	392251.2
Rice Mill	LPD	573538	1430548	2670826	465999.9	1162320	2170046	358461.5	894092.6	1669266
	m²	13947	34786.93	64947	11331.81	28264.38	52769.44	8716.779	21741.83	40591.88
Pharmaceutical	LPD	5175062	12829181	23761569	4204738	10423710	19306275	3234414	8018238	14850981
	m²	125843	311969.8	577814.8	102247.5	253475.4	469474.5	78651.89	194981.1	361134.3
Sea Food Industry	LPD	898447	2227286	4125269	729988.6	1809670	3351781	561529.7	1392054	2578293
	m²	21848	54161.37	100315	17751.28	44006.11	81505.92	13654.83	33850.86	62696.87
Chemical	LPD	894514	2618497	6079194	726793	2127529	4939345	559071.6	1636561	3799496
	m²	21752	63674.53	147829	17673.57	51735.55	120111	13595.05	39796.58	92393.11
Autocomponent including electroplating	LPD	987727	4083640	9783715	802528.5	3317957	7949268	617329.6	2552275	6114822
	m²	24019	99302.69	237912.6	19515.25	80683.44	193304	15011.73	62064.18	148695.3
Beer Industry	LPD	411192	1173616	2629866	334093.3	953562.6	2136767	256994.8	733509.7	1643667
	m²	9999	28539.04	63950.99	8124.213	23187.97	51960.18	6249.395	17836.9	39969.37
Total	m²	369391	1008674	2089758	305172	836025	1731656	240954	663376	1373553

From the above table,it can be noted Textile Processing Industry and Pharmaceutical Industry constitute a major share of around 29% and 27% respectively out of total realisable SWH potential for all the Industrial Segments in the year 2022 in realistic scenario. However, Dairy Industry, Auto Component Industries, Pulp & Paper Industry, Chemical Industry, Rice Processing Industry, Sea Food Processing Industry and Beer Industry constitute around 11%, 11%, 3.0%, 7.0%, 3.0%, 5.0% and 3.0% out of total realisable SWH potential for all the Industrial segments. States like Tamil Nadu (16.30%), Maharashtra (14.20%), Gujarat (12.32%), Andhra Pradesh (5.84%) Uttar Pradesh (5.00%), Punjab (4.97%) and West Bengal (3.78%) have share of about 65-70% out of total realisable SWH potential for all Industrial Segments.

State wise SWH Potential in M^2 in FY 2013, 2017 and 2022 under optimistic, realistic and pessimistic scenarios is provided in Table 12.1, 12.2 and 12.3 below respectively for each industrial sector. Overall realisable SWH potential for all industrial sectors is provided in LPD and M^2. Since, State wise information is not available for two sectors such as auto component industry and beer industry, only all India level potential number is provided in the table 12.1, 12.2 and 12.3. Overall realisable Industrial SWH potential in M^2in major States are also provided in Figure 12.1, indicating regional spread of the realisable SWH potential in realistic scenario.

Table 12.1: State wise and industry segment wise SWH Potential in FY 2013, 2017 and 2022 under Realistic Scenario

States/Union Teritorries	Industry Segment wise SWH Potential in Relastic Scenrario														
	Dairy Sector			Paper & Pulp Sector			Textile Processing Industry			Rice Mill Industry			Pharmaceutical Industry		
	2013	2017	2022	2013	2017	2022	2013	2017	2022	2013	2017	2022	2013	2017	2022
	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2
Andhra Pradesh	3487	8868	16985	780	2161	4649	3611	10351	23332	1627	4057	7575	7410	18369	34022
Arunachal Pradesh	9	22	43	0	0	0	0	0	0	0	0	0	0	0	0
Assam	274	698	1336	372	1032	2220	3	8	17	458	1143	2133	347	859	1591
Bihar	2162	5499	10532	22	60	129	0	0	0	639	1593	2974	989	2451	4539
Goa	21	55	105	0	0	0	0	0	0	0	0	0	0	0	0
Gujarat	3056	7771	14884	1577	4371	9404	6461	18517	41739	149	370	692	15553	38557	71413
Haryana	2093	5324	10197	205	567	1220	2606	7471	16839	377	940	1755	2925	7252	13431
Himachal Pradesh	322	819	1569	83	231	496	1989	5702	12852	88	220	411	3710	9197	17034
J & K	546	1388	2659	6	15	33	58	165	373	0	0	0	387	960	1778
Karnataka	1653	4205	8054	543	1506	3240	2257	6468	14578	434	1083	2021	3832	9500	17596
Kerala	889	2262	4332	264	732	1575	899	2578	5811	67	168	314	2252	5584	10342
Madhya Pradesh	2498	6352	12167	270	748	1610	4056	11626	26206	178	444	830	3404	8439	15630
Maharashtra	2716	6908	13232	1423	3944	8486	8789	25192	56784	260	650	1213	31993	79312	146898
Manipur	28	72	138	0	0	0	0	0	0	57	142	266	0	0	0
Meghalaya	28	71	137	0	0	0	0	0	0	0	0	0	0	0	0
Mizoram	6	16	30	0	0	0	0	0	0	88	220	411	0	0	0
Nagaland	19	49	94	36	100	215	0	0	0	0	0	0	0	0	0
Orissa	609	1549	2968	299	829	1783	67	192	432	778	1940	3623	734	1819	3369
Punjab	3420	8699	16661	1150	3187	6858	8029	23014	51874	1257	3134	5851	0	0	0
Rajasthan	3458	8795	16845	21	59	128	2651	7599	17128	0	0	0	1814	4497	8330
Sikkim	18	45	87	0	0	0	0	0	0	0	0	0	0	0	0
Tamil Nadu	2067	5257	10069	928	2571	5532	34077	97671	220152	592	1476	2756	5810	14402	26675
Tripura	35	89	170	0	0	0	0	0	0	0	0	0	0	0	0
Uttar Pradesh	7119	18104	34675	1295	3588	7719	1486	4259	9601	1496	3732	6969	4423	10966	20310
West Bengal	1522	3870	7412	284	787	1694	446	1278	2880	1718	4285	8001	7705	19102	35379
A&N Islands	9	24	46	0	0	0	0	0	0	0	0	0	0	0	0
Chandigarh	17	44	83	0	0	0	0	0	0	88	220	411	652	1617	2995
D&N Haveli	1	4	7	0	0	0	912	2613	5890	0	0	0	0	0	0
Daman & Diu	0	1	2	0	0	0	2	6	13	0	0	0	0	0	0
Delhi	104	264	506	0	0	0	0	0	0	0	0	0	5351	13265	24569
Lakshadweep	1	2	4	0	0	0	0	0	0	0	0	0	0	0	0
Pondicherry	17	43	82	13	36	78	492	1410	3179	0	0	0	0	0	0
Chhattisgarh	331	841	1612	59	164	353	0	0	0	501	1251	2335	132	328	608
Uttaranchal	448	1140	2183	449	1245	2678	0	0	0	88	220	411	2599	6443	11933
Jharkhand	534	1358	2602	0	0	0	38	110	248	391	974	1819	224	556	1030
All India	39520	100508	192506	10079	27934	60098	78930	226230	509927	11332	28264	52769	102247	253475	469475

States/Union Teritorries	Industry Segment wise SWH Potential in Relastic Scenrario																					State wise Overall SWH Potential in Indian Industries (Realistic Scenario)		
	Sea Food Processing Ind.							Chemical Industry							Autocomponent Industry			Beer Industry						
	Statewise Seafood	2013		2017		2022		Statewise Chemical	2013		2017		2022		2013	2017	2022	2013	2017	2022	2013	2017	2022	
		LPD	M^2	LPD	M^2	LPD	M^2		LPD	M^2	LPD	M^2	LPD	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	
Andhra Pradesh	13.0%	95136	2313	235847	5735	436824	10622	3.3%	24195	588	70826	1722	164432	3999							19816	51264	101184	
Arunachal Pradesh	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							9	22	43	
Assam	0.0%	0	0	0	0	0	0	1.3%	9504	231	27820	677	64589	1571							1685	4415	8869	
Bihar	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							3811	9602	18174	
Goa	1.8%	12807	311	31749	772	58803	1430	0.0%	0	0	0	0	0	0							333	827	1535	
Gujarat	13.8%	100625	2447	249453	6066	462025	11235	53.3%	387378	9420	1133965	27575	2632653	64019							38662	103228	213385	
Haryana	0.0%	0	0	0	0	0	0	0.1%	576	14	1686	41	3913	95							8220	21594	43537	
Himachal Pradesh	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							6193	16169	32363	
J & K	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							996	2529	4843	
Karnataka	3.5%	25614	623	63497	1544	117606	2860	0.8%	5896	143	17259	420	40069	974							9486	24725	49324	
Kerala	31.1%	226864	5517	562404	13676	1041656	25330	2.4%	17521	426	51289	1247	119073	2896							10316	26247	50600	
Madhya Pradesh	0.0%	0	0	0	0	0	0	4.4%	32300	785	94552	2299	219516	5338							11192	29909	61780	
Maharashtra	10.3%	75011	1824	185956	4522	344419	8375	9.1%	66111	1608	193527	4706	449299	10926							48614	125235	245913	
Manipur	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							86	215	404	
Meghalaya	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							28	71	137	
Mizoram	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							94	236	441	
Nagaland	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							55	149	309	
Orissa	5.3%	38420	934	95246	2316	176410	4290	0.5%	3485	85	10200	248	23681	576							3506	8893	17040	
Punjab	0.0%	0	0	0	0	0	0	4.1%	29533	718	86451	2102	200708	4881							14574	40136	86124	
Rajasthan	0.0%	0	0	0	0	0	0	3.2%	23456	570	68664	1670	159412	3876							8515	22620	46308	
Sikkim	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							18	45	87	
Tamil Nadu	12.0%	87818	2135	217705	5294	403222	9805	6.1%	44290	1077	129648	3153	300996	7319							46685	129824	282308	
Tripura	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							35	89	170	
Uttar Pradesh	0.0%	0	0	0	0	0	0	6.3%	46040	1120	134772	3277	312891	7609							16939	43927	86883	
West Bengal	9.3%	67693	1646	167814	4081	310817	7558	2.1%	15413	375	45119	1097	104749	2547							13696	34499	65470	
A&N Islands	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							9	24	46	
Chandigarh	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							758	1881	3489	
D&N Haveli	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							913	2617	5897	
Daman & Diu	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							2	7	15	
Delhi	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							5455	13529	25075	
Lakshadweep	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							1	2	4	
Pondicherry	0.0%	0	0	0	0	0	0	1.8%	13396	326	39214	954	91040	2214							848	2443	5552	
Chhattisgarh	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							1024	2585	4908	
Uttaranchal	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							3584	9048	17205	
Jharkhand	0.0%	0	0	0	0	0	0	1.1%	7699	187	22538	548	52325	1272							1375	3547	6971	
All India	100%	729989	17751	1809670	44006	3351781	81506	100%	726793	17674	2127529	51736	4939345	120111	19515	80683	193304	8124	23188	51960	305172	836025	1731656	

Source: ABPS Infra Research & Analysis

Table 12.2: State wise and industry segment wise SWH Potential in FY 2013, 2017 and 2022 under Optimistic Scenario

States/Union Teritorries	Industry Segment wise SWH Potential in Optimistic Scenario														
	Dairy Sector			Paper & Pulp Sector			Textile Processing Industry			Rice Mill Industry			Pharmaceutical Industry		
	2013	2017	2022	2013	2017	2022	2013	2017	2022	2013	2017	2022	2013	2017	2022
	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2
Andhra Pradesh	3744	9125	17242	960	2660	5722	4445	12740	28716	2002	4994	9323	9120	22608	41873
Arunachal Pradesh	9	23	43	0	0	0	0	0	0	0	0	0	0	0	0
Assam	295	718	1357	458	1270	2732	3	9	21	564	1406	2625	427	1057	1958
Bihar	2322	5658	10691	27	74	159	0	0	0	786	1960	3660	1217	3016	5587
Goa	23	56	106	0	0	0	0	0	0	0	0	0	0	0	0
Gujarat	3281	7996	15109	1941	5380	11574	7951	22791	51371	183	456	851	19142	47455	87893
Haryana	2248	5478	10351	252	698	1501	3208	9194	20725	464	1157	2161	3600	8925	16530
Himachal Pradesh	346	843	1593	102	284	611	2448	7018	15818	109	271	506	4566	11319	20965
J & K	586	1428	2699	7	19	41	71	203	458	0	0	0	477	1182	2189
Karnataka	1775	4327	8176	669	1853	3987	2777	7960	17943	534	1333	2488	4717	11693	21657
Kerala	955	2328	4398	325	901	1939	1107	3173	7152	83	207	386	2772	6873	12729
Madhya Pradesh	2682	6536	12351	332	921	1981	4992	14309	32253	219	547	1021	4190	10387	19237
Maharashtra	2917	7109	13432	1751	4854	10444	10818	31006	69888	321	800	1493	39376	97615	180798
Manipur	31	74	141	0	0	0	0	0	0	70	175	327	0	0	0
Meghalaya	30	73	139	0	0	0	0	0	0	0	0	0	0	0	0
Mizoram	7	16	31	0	0	0	0	0	0	109	271	506	0	0	0
Nagaland	21	51	95	44	123	264	0	0	0	0	0	0	0	0	0
Orissa	654	1594	3012	368	1020	2194	82	236	532	957	2388	4459	903	2239	4147
Punjab	3673	8951	16913	1415	3923	8440	9882	28325	63844	1547	3857	7202	0	0	0
Rajasthan	3713	9050	17100	26	73	157	3263	9353	21081	0	0	0	2233	5535	10252
Sikkim	19	47	88	0	0	0	0	0	0	0	0	0	0	0	0
Tamil Nadu	2219	5409	10221	1142	3165	6809	41940	120210	270956	728	1816	3391	7150	17726	32830
Tripura	38	92	173	0	0	0	0	0	0	0	0	0	0	0	0
Uttar Pradesh	7644	18629	35200	1593	4416	9501	1829	5242	11816	1842	4594	8577	5444	13496	24997
West Bengal	1634	3982	7524	350	969	2085	549	1572	3544	2115	5274	9847	9483	23510	43543
A&N Islands	10	25	47	0	0	0	0	0	0	0	0	0	0	0	0
Chandigarh	18	45	85	0	0	0	0	0	0	109	271	506	803	1990	3686
D&N Haveli	2	4	7	0	0	0	1122	3216	7249	0	0	0	0	0	0
Daman & Diu	0	1	2	0	0	0	3	7	16	0	0	0	0	0	0
Delhi	112	272	513	0	0	0	0	0	0	0	0	0	6586	16326	30239
Lakshadweep	1	2	4	0	0	0	0	0	0	0	0	0	0	0	0
Pondicherry	18	44	83	16	45	96	606	1736	3912	0	0	0	0	0	0
Chhattisgarh	355	866	1636	73	202	434	0	0	0	617	1539	2874	163	404	749
Uttaranchal	481	1173	2216	553	1532	3296	0	0	0	109	271	506	3199	7930	14687
Jharkhand	574	1398	2641	0	0	0	47	135	305	481	1199	2239	276	684	1267
All India	42435	103422	195420	12405	34380	73967	97144	278437	627602	13947	34787	64947	125843	311970	577815

States/Union Teritorries	Industry Segment wise SWH Potential in Optimistic Scenario																				State wise Overall SWH Potential in Indian Industries (Optimistic Scenario)		
	Sea Food Processing Ind.							Chemical Industry							Autocomponent Industry			Beer Industry					
	Statewise Seafood	2013		2017		2022		Statewise Chemical	2013		2017		2022		2013	2017	2022	2013	2017	2022	2013	2017	2022
		LPD	M^2	LPD	M^2	LPD	M^2		LPD	M^2	LPD	M^2	LPD	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2
Andhra Pradesh	13.0%	2847	2847	235847	7059	436824	13074	3.3%	24195	724	70826	2120	164432	4921							23842	61305	120872
Arunachal Pradesh	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							9	23	43
Assam	0.0%	0	0	0	0	0	0	1.3%	9504	284	27820	833	64589	1933							2031	5294	10627
Bihar	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							4351	10709	20097
Goa	1.8%	383	383	31749	950	58803	1760	0.0%	0	0	0	0	0	0							406	1006	1866
Gujarat	13.8%	3012	3012	249453	7466	462025	13828	53.3%	387378	11594	1133965	33938	2632653	78792							47104	125481	259418
Haryana	0.0%	0	0	0	0	0	0	0.1%	576	17	1686	50	3913	117							9789	25503	51385
Himachal Pradesh	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							7571	19735	39493
J & K	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							1141	2832	5387
Karnataka	3.5%	767	767	63497	1900	117606	3520	0.8%	5896	176	17259	517	40069	1199							11415	29583	58969
Kerala	31.1%	6790	6790	562404	16832	1041656	31176	2.4%	17521	524	51289	1535	119073	3564							12556	31848	61343
Madhya Pradesh	0.0%	0	0	0	0	0	0	4.4%	32300	967	94552	2830	219516	6570							13382	35530	73414
Maharashtra	10.3%	2245	2245	185956	5565	344419	10308	9.1%	66111	1979	193527	5792	449299	13447							59406	152741	299809
Manipur	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							101	250	468
Meghalaya	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							30	73	139
Mizoram	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							115	287	536
Nagaland	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							65	173	360
Orissa	5.3%	1150	1150	95246	2851	176410	5280	0.5%	3485	104	10200	305	23681	709							4219	10633	20332
Punjab	0.0%	0	0	0	0	0	0	4.1%	29533	884	86451	2587	200708	6007							17401	47643	102406
Rajasthan	0.0%	0	0	0	0	0	0	3.2%	23456	702	68664	2055	159412	4771							9938	26066	53362
Sikkim	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							19	47	88
Tamil Nadu	12.0%	2628	2628	217705	6516	403222	12068	6.1%	44290	1326	129648	3880	300996	9008							57134	158722	345284
Tripura	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							38	92	173
Uttar Pradesh	0.0%	0	0	0	0	0	0	6.3%	46040	1378	134772	4034	312891	9364							19730	50411	99455
West Bengal	9.3%	2026	2026	167814	5022	310817	9302	2.1%	15413	461	45119	1350	104749	3135							16617	41680	78981
A&N Islands	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							10	25	47
Chandigarh	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							930	2306	4277
D&N Haveli	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							1124	3220	7257
Daman & Diu	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							3	8	18
Delhi	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							6697	16598	30752
Lakshadweep	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							1	2	4
Pondicherry	0.0%	0	0	0	0	0	0	1.8%	13396	401	39214	1174	91040	2725							1041	2998	6816
Chhattisgarh	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							1208	3011	5693
Uttaranchal	0.0%	0	0	0	0	0	0	0.0%	0	0	0	0	0	0							4341	10905	20705
Jharkhand	0.0%	0	0	0	0	0	0	1.1%	7699	230	22538	675	52325	1566							1608	4091	8019
All India	100%	21848	21848	1809670	54161	3351781	100315	100%	726793	21752	2127529	63675	4939345	147829	24019	99303	237913	9999	28539	63951	369391	1008674	2089758

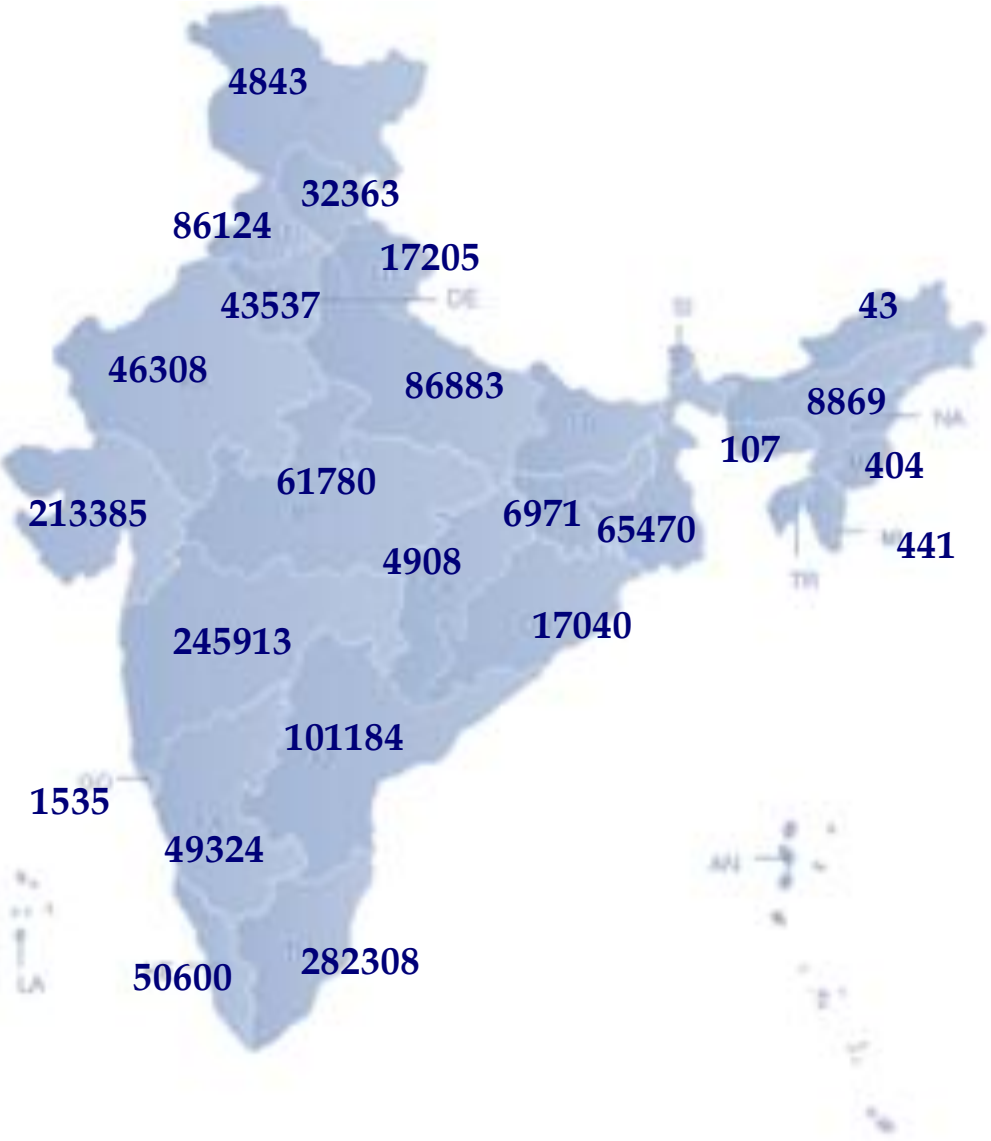
Source: ABPS Infra Research & Analysis

Table 12.3: State wise and industry segment wise SWH Potential in FY 2013, 2017 and 2022 under Pessimistic Scenario

States/Union Teritorries	Industry Segment wise SWH Potential in Pessimistic Scenario														
	Dairy Sector			Paper & Pulp Sector			Textile Processing Industry			Rice Mill Industry			Pharmaceutical Industry		
	2013	2017	2022	2013	2017	2022	2013	2017	2022	2013	2017	2022	2013	2017	2022
	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2
Andhra Pradesh	3230	8611	16728	600	1662	3576	2778	7963	17948	1251	3121	5827	5700	14130	26171
Arunachal Pradesh	8	22	42	0	0	0	0	0	0	0	0	0	0	0	0
Assam	254	678	1316	286	794	1708	2	6	13	352	879	1641	267	661	1224
Bihar	2003	5339	10373	17	46	99	0	0	0	491	1225	2287	760	1885	3492
Goa	20	53	103	0	0	0	0	0	0	0	0	0	0	0	0
Gujarat	2830	7546	14659	1213	3362	7234	4970	14244	32107	114	285	532	11964	29659	54933
Haryana	1939	5169	10042	157	436	938	2005	5747	12953	290	723	1350	2250	5578	10331
Himachal Pradesh	298	795	1545	64	177	382	1530	4386	9886	68	169	316	2854	7075	13103
J & K	506	1348	2618	4	12	26	44	127	287	0	0	0	298	739	1368
Karnataka	1532	4083	7932	418	1158	2492	1736	4975	11214	334	833	1555	2948	7308	13535
Kerala	824	2196	4267	203	563	1212	692	1983	4470	52	129	241	1733	4295	7956
Madhya Pradesh	2314	6168	11982	208	576	1238	3120	8943	20158	137	342	638	2619	6492	12023
Maharashtra	2516	6708	13031	1095	3034	6527	6761	19379	43680	200	500	933	24610	61009	112998
Manipur	26	70	136	0	0	0	0	0	0	44	110	205	0	0	0
Meghalaya	26	69	135	0	0	0	0	0	0	0	0	0	0	0	0
Mizoram	6	15	30	0	0	0	0	0	0	68	169	316	0	0	0
Nagaland	18	48	93	28	77	165	0	0	0	0	0	0	0	0	0
Orissa	564	1504	2923	230	637	1371	51	147	332	598	1493	2787	564	1399	2592
Punjab	3168	8446	16408	885	2452	5275	6176	17703	39903	967	2411	4501	0	0	0
Rajasthan	3203	8540	16590	16	46	98	2039	5845	13176	0	0	0	1396	3460	6408
Sikkim	17	44	86	0	0	0	0	0	0	0	0	0	0	0	0
Tamil Nadu	1915	5104	9916	714	1978	4256	26213	75131	169348	455	1135	2120	4469	11078	20519
Tripura	32	86	168	0	0	0	0	0	0	0	0	0	0	0	0
Uttar Pradesh	6594	17579	34150	996	2760	5938	1143	3276	7385	1151	2871	5360	3403	8435	15623
West Bengal	1409	3758	7300	219	606	1303	343	983	2215	1322	3296	6154	5927	14694	27215
A&N Islands	9	23	45	0	0	0	0	0	0	0	0	0	0	0	0
Chandigarh	16	42	82	0	0	0	0	0	0	68	169	316	502	1244	2304
D&N Haveli	1	4	7	0	0	0	701	2010	4531	0	0	0	0	0	0
Daman & Diu	0	1	2	0	0	0	2	5	10	0	0	0	0	0	0
Delhi	96	256	498	0	0	0	0	0	0	0	0	0	4116	10204	18899
Lakshadweep	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0
Pondicherry	16	41	80	10	28	60	378	1085	2445	0	0	0	0	0	0
Chhattisgarh	306	817	1587	46	126	271	0	0	0	386	962	1796	102	253	468
Uttaranchal	415	1107	2150	345	957	2060	0	0	0	68	169	316	1999	4956	9180
Jharkhand	495	1319	2563	0	0	0	30	85	191	301	750	1399	172	428	792
All India	36606	97594	189591	7753	21488	46229	60715	174023	392251	8717	21742	40592	78652	194981	361134

States/Union Teritorries	Industry Segment wise SWH Potential in Pessimistic Scenario												State wise Overall SWH Potential in Indian Industries (Pessimistic Scenario)		
	Sea Food Processing Ind.			Chemical Industry			Autocomponent Industry			Beer Industry					
	2013	2017	2022	2013	2017	2022	2013	2017	2022	2013	2017	2022	2013	2017	2022
	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2	M^2
Andhra Pradesh	1780	4412	8171	453	1325	3076							15791	41223	81497
Arunachal Pradesh	0	0	0	0	0	0							8	22	42
Assam	0	0	0	178	520	1208							1339	3537	7110
Bihar	0	0	0	0	0	0							3271	8496	16251
Goa	240	594	1100	0	0	0							259	647	1203
Gujarat	1882	4666	8642	7246	21211	49245							30220	80974	167352
Haryana	0	0	0	11	32	73							6652	17685	35688
Himachal Pradesh	0	0	0	0	0	0							4814	12603	25233
J & K	0	0	0	0	0	0							852	2225	4298
Karnataka	479	1188	2200	110	323	750							7556	19868	39678
Kerala	4244	10520	19485	328	959	2227							8075	20647	39857
Madhya Pradesh	0	0	0	604	1769	4106							9001	24289	50147
Maharashtra	1403	3478	6443	1237	3620	8404							37822	97728	192017
Manipur	0	0	0	0	0	0							70	180	341
Meghalaya	0	0	0	0	0	0							26	69	135
Mizoram	0	0	0	0	0	0							74	185	346
Nagaland	0	0	0	0	0	0							46	125	258
Orissa	719	1782	3300	65	191	443							2792	7154	13747
Punjab	0	0	0	552	1617	3754							11748	32629	69842
Rajasthan	0	0	0	439	1284	2982							7093	19175	39254
Sikkim	0	0	0	0	0	0							17	44	86
Tamil Nadu	1643	4072	7542	828	2425	5630							36236	100925	219331
Tripura	0	0	0	0	0	0							32	86	168
Uttar Pradesh	0	0	0	861	2521	5853							14147	37443	74310
West Bengal	1266	3139	5814	288	844	1959							10774	27319	51960
A&N Islands	0	0	0	0	0	0							9	23	45
Chandigarh	0	0	0	0	0	0							586	1455	2702
D&N Haveli	0	0	0	0	0	0							703	2014	4538
Daman & Diu	0	0	0	0	0	0							2	5	12
Delhi	0	0	0	0	0	0							4212	10460	19397
Lakshadweep	0	0	0	0	0	0							1	2	3
Pondicherry	0	0	0	251	734	1703							655	1888	4289
Chhattisgarh	0	0	0	0	0	0							840	2158	4123
Uttaranchal	0	0	0	0	0	0							2828	7190	13705
Jharkhand	0	0	0	144	422	979							1141	3002	5924
All India	13655	33851	62697	13595	39797	92393	15012	62064	148695	6249	17837	39969	240954	663376	1373553

Figure 14.1 :Overall Industrial SWH potential in M²



13 ACTION PLAN FOR PROMOTION OF SWHS IN INDUSTRIAL SECTORS

In this Chapter, ABPS Infra has presented Action Plan for realization of SWH potential in the Industrial Sector. In recent years, India has witnessed significant growth in installations of SWHS. A total 3.53 million square meter of SWH collector area has so far been installed in the country. Several initiatives taken in the last few years have resulted in acceleration in the pace of deployment in SWH. The Ministry of New and Renewable Energy has been at the forefront of devising promotional measures for greater off-take of SWH for different consumer categories. A target of 7 million square meter has been set for the first phase of Jawaharlal Nehru National Solar Mission (2010-13) and a goal of 20 million square meter for 2022. Even though solar water heating systems are mainly used today for providing hot water to residential and commercial sectors, the market assessment survey in different Industrial sectors clearly highlights that Industrial sectors also offer huge potential for integration of SWH system for various applications and therefore cannot be ignored. Moreover, a remarkable share of its heat demand is needed in the low and medium temperature range and this is true for many industrial sectors (Dairy, Sea Food, Pulp & Paper, Pharmaceuticals, Textile Processing etc.) and for several processes (cleaning, drying, pulping, dyeing etc.).

Studies carried out to assess the overall realisable SWH potential in the various industrial sectors highlight various low and medium temperature applications where SWHS can be easily integrated. In order to realise this potential SWH and increase the penetration of SWH in Industrial Sectors, following actions have been proposed.

13.1 Prioritization of Industrial Sectors

This Study highlights that there is a promising, suitable and so far almost unexploited market for integration of SWHs in the various industrial sectors. However, potential for integration of SWH in the different industrial sectors varies significantly. Hence, it is important to identify the most suitable and the most representative industrial sectors and prioritise the same to exploit this potential. In order to prioritise the various industrial sectors, we have done analysis of the following criteria:

- Industrial sectors using expensive sources of energy (e.g. HSD, LPG, LDO etc.) andthereby having higher cost of energy per million kCal of useful energy (i.e.

after considering conversion efficiency) are the most suitable for SWHS. Market assessment survey highlighted that Pharmaceutical Sectoruses high cost energy and its cost of energy per million kCal of useful energy is also the maximum. Based on the analysis of the data collected from the industries, it can be seen that in pharmaceutical industry, mainly electricity, HSD & LDO and LPG are being utilized to meet thermal as well as electrical energy requirement. Sectors such as textilesand auto component also consume significant amount of liquid fuels (HSD, FO, LDO) to meet thermal energy requirement of their processes.

- Industrial sectors which offer maximum potential for the integration of SWHS to cater their low and medium temperature hot water requirement.
- Industrial Sectors in which space constraints are limited. Based on the analysis of the nine industrial sectors, it can be seen that pharmaceutical industries has both potential and space available to realize that potential, whereas, sectors such as textile processing and pulp & paper has potential for integration of SWHS, however no space is the biggest constraint.
- Industrial sectors having special requirements such as hygienic conditionsviz. foodprocessing industries (dairy, sea food and beer etc.) and pharmaceutical should be given priority.

Considering the abovementioned important criteria and analysis carried out for the nine industrial sectors, we have prioritised food processing industries (mainly Dairy), Pharmaceutical, Auto Components, Textile Processing for this purpose. These industries offer maximum potential and space for the integration of the SWH systems for various heating applications. Cost of Energy per Million Kcal of Useful energy is also higher in these industrial sectors. Hence, it is suggested that MNRE should identify major clusters in these industrial sectors and develop demonstration projects using different technologies for integration of SWHS for these industries. Such projects should clearly demonstrate cost effectiveness of SWH under existing subsidy schemes of Government of India. While developing these projects two specific business models; manufacturer as a system integrator and the cluster association as a program administrator should be developed and tested.

13.2 Development of applications for industries covered under PAT

MNRE should take into consideration other policies of the Government of India, which encourage integration of renewable energy sources. One such policy is

'Perform, Achieve and Trade' (PAT) mechanism under NMEEE under, which energy efficiency improvement targets (Reduction in Specific Energy Consumption) for nine industrial sectors will be specified by the Government of India. The companies will have to achieve these targets over a period of three years. Most of these sectors are continuous process industries. Industrial sectors such as Thermal Power Plant, Pulp and Paper, Textile, Cement, Chlor Alkali, Iron & Steel, Fertiliser, Aluminium are covered under PAT scheme. Bureau of Energy EfficiencyofGovernment of India is presently in the process of setting targets for around 600 industrial units in these nine industrial sectors. In this regard, BEE has collected five years data of their energy consumption and production details and developed baseline for each industrial unit. BEE has recently appointed Consultants to conduct a baseline energy audit to find out the energy savings potential in that particular industry. BEE is also creating awareness about the PAT scheme by organising various workshops and training programmes in different States and industrial clusters. These industries could use SWH systems to meet their direct and indirect process heat requirement, which would help them in reducing their specific energy consumption and getting the target set by BEE. In this regard, MNRE may also associate with BEE to create awareness about usage of SWH to reduce specific energy consumption.

Industrial sectors covered under PAT schemes are continuous process industries. Integration of SWH systems in the continuous process may not be an easy task. In order to demonstrate the feasibility of integration of SWH in continuous process industries, MNRE may also consider developing demonstration projects for these industrial sectors, which are covered under PAT and has potential for integration of SWH systems in association with BEE. We have done potential assessment of SWH systems for two industrial sectors that are also covered under PAT scheme. We would like to highlight that remaining industrial sectors such as fertilisers, cement, thermal power plant also offer potential for integration of SWHS to reduce / replace quantity of thermal energy required for the various preheating applications such as make up water requirement for boiler etc.

13.3 Awareness creation workshops for SME clusters

Generally, awareness about the technology and willingness to deploy new technologies is less among Small and Medium Enterprises (SME). To overcome this barrier, MNRE may consider organisation of workshops&awareness campaigns at

major SME clusters. These workshops should be conducted in association with industrial associations and following issues should be highlighted:

- Real cost of heat production and use of conventional energy sources and its relevance in the management of total industry costs; and
- Benefits of using appropriate solar thermal technology

13.4 Utility Demand Side Management Programs

There exists potential for SWHS to reduce electrical load by encouraging shift from electrical heating to solar heating. While such potential is not significant in industry, it could be used effectively by utilities with high level of industrial consumption. Recently, Forum of Regulator has issued a draft Demand Side Management Regulations. Electricity Regulatory Commission of the State can use this document as reference document and issue and notify State specific DSM Regulations. On Notification of this Regulation, it will be mandatory for the distribution utilities to prepare DSM plan and submit along with their Multi Year Tariff Petition to Electricity Regulatory Commission.

This DSM plan should contain information related to various sector specific DSM projects (industrial, residential, commercial etc.) along with their cost benefit analysis, measurement and verification etc. Distribution Utility will have to prepare and submit this plan to the State Electricity Regulatory Commission for its approval. Distribution Utilities with higher industrial consumption may consider promotion of SWH systems by industrial units while developing DSM programme. MNRE may provide necessary assistance to distribution companies in identification of target companies and appropriate technologies.

13.5 Integration of indirect heating applications

Based on the market assessment survey, it has been observed that industrial sectors offer potential for both direct as well as indirect heating applications. Industrial Sector such as auto component requires steam for heating the electrolyte solution. Temperature requirement of electrolyte solution is in the range of 50 to 70 degree C. It is possible to heat the electrolyte solution by means of hot water of 80 degree C (indirect heating) generated through installation of SWH systems. However, integration of SWH systems for such indirect heating application is difficult and complicated task. Based on the interaction with SWH manufacturers and industrial

experts, it was observed that very few installations have been commissioned for the indirect heating applications in the Indian industrial sectors.

Hence, it is suggested that MNRE may consider capacity building programmes for various stakeholders such as SWH manufacturers, industrial experts to explore untapped potential through indirect applications.

13.6 Promotion of ESCO route for deployment of SWH

During market assessment survey, it was also observed that higher initial capital cost of SWHS is one of the critical barriers, which is hampering the penetration of SWHS in industrial sector. In order to overcome this issue, internationally some of the projects have been implemented through the involvement of Energy Service Companies. In India, Energy Service Companies can also play an important role in increasing the penetration of SWH in Industrial Sectors.

In this regard, MNRE can initiate the process of accreditation of the companies as "Energy Service Companies",which has a potential to provide innovative solutions for the integration of SWHS in the industrial sectors. However, accreditation and empanelment of firms as ESCO may be a lengthy and cumbersome procedure. Also, in India, Bureau of Energy Efficiency has empanelled and accredited 89 firms as "Energy Service Companies" (ESCO) as on 21/10/2010. These firms have been categorised in to five main categories based on their technical capability, financial strength and past experience in the implementation of energy efficiency and energy conservation projects. Hence, it is suggested that MNRE may consider the companies, which are already empanelled with Bureau of Energy Efficiency as ESCO firm and have also worked in the area of renewable energy sector. This may help in quick deployment of SWH systems through ESCO mode.

13.7 Identification and promotion of high temperature applications

In Industrial Sectors opportunities exist not only forlow and medium temperature applications, but also for higher temperature applications. Rather, potential for some high temperature applications is huge.

Applications such as generation of chilled water through installation of SWHS based VAM for process cooling and comfort cooling, high temperature hot water requirement for process heating, high temperature hot air requirement are some of the

examples of the same. Estimation and realisation of potential of high temperature applications will contribute significantly in achieving goal of 20 million square meter for the year 2022 set under JNNSM. Hence, it is suggested that MNRE should initiate a separate study to assess the market potential for SWH systems in Industrial sectors targeting higher temperature applications.

14 LIST OF ANNEXURES

14.1 Annexure – I – International Case Studies

Solar Water Heating Systems have been implemented for the variety of applications in the different industrial sectors in different parts of world. Within the scope of the assignment, it was necessary to gather details of existing SWH industrial applications, implementation models, identify impact and limitation and to evaluate the same in Indian context. The objective of this exercise is to overcome the barrier of limited knowledge about SWH applications in the industrial sectors in India. ABPS Infra has collected information through various primary and secondary sources for identification of the various SWH projects implemented in the different parts of the world in different industrial sectors. Based on the information collected, ABPS Infra has prepared five detailed case studies on SWHS implemented in the different industrial sectors for the varied applications. These Case Studies mainly highlight project implementing agency, focus of the project, project objective, technology used, drivers for implementations, barriers addressed, overall effective assessment, cost benefit analysis and applicability of the same projects in the different industrial sectors. Each of these case studies is described in the subsequent section:

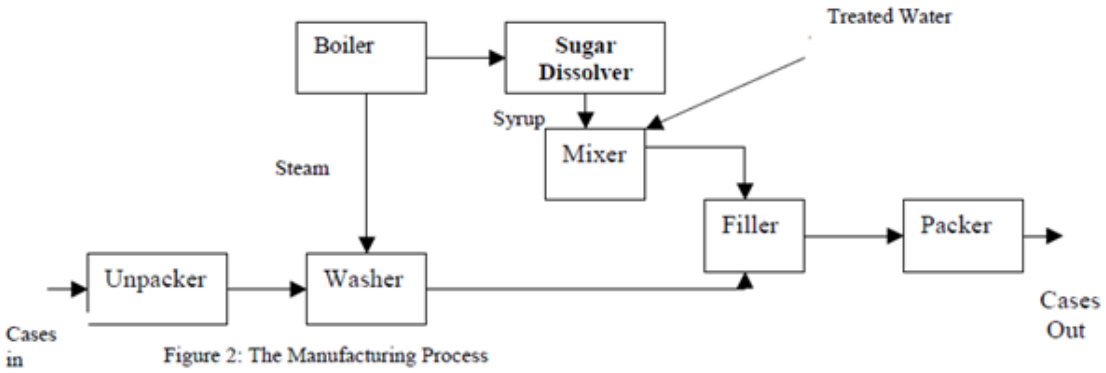
14.1.1 Uganda – Food Processing Industry

Location of Project	Kampala, Uganda
Year Project Implemented	2004
Name of Project Implementer	Crown Beverages Limited
Type of Project Implementer	Industry Owner
Industrial Segment Targeted	**Food Industry (Beverages)**
Project Objective	Reduce Fossil Fuel Consumption & Carbon Emission
Project Target	Low Temperature Preheating Application
Specific Technology Used	**FPC (Thermo Siphon SWH System)**

DESCRIPTION OF THE PROJECT

Crown Beverages limited (Uganda) holds the franchise for Pepsi-Cola and produces about 25 thousand bottles of soda daily. Typical process flow diagram of the manufacturing process is provided below in Figure 14.2:

Figure 14.2 Process Flow Diagram of Crown Beverages Limited



As shown in Figure 14.2, the manufacutirng process of the beverage industry broadly classified in to the four major sections:

- Boiler Section: Furnace Oil is utilised as a fuel in the boiler to generate the steam. Steam is being used to cater the heating requirement of the entire process. Steam is also utilised to heat the make up water up to 70^0C and same is being fed to the boiler.
- Sugar Disolver: Sugar Disolver is a vessel, where sugar is dissoleved in hot water to prepare the sugar syrup. Hot water of around 80^0C is required in the sugar disolver. Hot water is generated through utilisation of steam.
- Cleaning Process: Cleaning Process mainly involves washing of the bottles. In order to wash the bottles, they require hot water of around 85^0C.
- Rinse Section: Rinse section is also the part of cleaning plant only and require maximum amount of water. They require hot water at around 40^0C in the first rinse section of the bottle washer. Water is being heated from 20^0C to 40^0C with the help of steam.

As discussed above, hot water of the different temperature is required in different section of the processes. Temperature of the hot water in different sections of the

process and quanitty of furnace oil which is required to heat the same is provided in the table 14.1 below:

Table14.1 : Data on CBL Industrial Processes

Section	Required Water Temp. (^{o}C)	Furnace Oil Consumption (m^3/annum)	Oil Expenditure (USD/annum)	Oil Expenditure (%)
Rinse	40	176.7	61,484	54.7
Sugar dissolver	85	30.2	10,508	9.3
CIP	80	8.7	3,027	2.7
Make up water tank	70	5.0	1,739	1.5
Bottle washer I	60	9.7	3,375	3.0
Bottle washer II	80	24.2	8,420	7.5
Bottle washer III	65	14.5	5,044	4.5
Total		**323.1**	**112,400**	**100**

From the above table, it can be seen that rinse section required maximum water followed by sugar disolver and washing section. In order to reduce furnace oil consumption, SWHS systems was installed to pre heat the water from ambient temperature of 20^0C to 60^0C. The solar collector was mounted on the roof and was connected to a circuit containing water with propylene glycol anti-freeze. The heated liquid flows around the circuit, either under the action of a pump to warm the main hot water tank, or by a thermo-syphoning action to warm a solar water storage tank that then feeds the hot water tank.

As a first step, the company also installed a recyclying system for the rinse section which resulted in reduction in the water consumption by upto 50% of orignial requirement.Further, it installed separate tank for the quantity of hot water required at 40^0C in the rinse section. For rest of the sections such as sugar dissolver, make up water tank and bottle washer, one more tank was provided. The water in this tank was heated to a temperature of 60^0C thourgh the SWH systems. Water from this tank was then suplied to the sections where heating was supplemented by furnace oil. Cost benefit analysis of installation of SWHS is provided in the Table 14.2:

ECONOMICS OF SWHS	
Energy used to heat 1 liter of water by 1^0C	1.16 Who
Equivalent energy of 1 ltr of furnace oil (@75% of boiler efficiency)	7.5 kWh
Energy needed to vaporize one liter of water	627 Wh
Energy used to produce steam from one liter of water (20 to 120^0C) =(1 x 1.16 x (120-20)	116 Wh
Total energy required to produce steam from one liter of water	743 Wh
Quantity of furnace oil required to vaporize one liter of water= (0.743/7.5)	0.1 litre
Total Furnace Oil Consumption per day	1185. 2 liter
Cost of the furnace oil (USD)	0.3 /liter
Cost of Furnace Oil per year (@ 6 working days per week) (USD)	USD 112,400
One Sq. M of Collector provides	3 kWh /day
Total energy consumption per day	7592 kWh/day
Area of Solar Collector required, Sq. M	2530.67 Sq. M.
Cost of installation of SWH systems including panels, pipes and other accessories (USD/Sq. M)	USD 250
Total Cost of Installing 2530.68 Sq. M. Collector, USD	USD 632668
Simple Payback Period, Years	5.62 Years
Total Cost of Furnace Oil for the twenty years (USD)	USD 2247700
Savings during the Life Cycle of the Project (20 years) (USD)	USD1,615,032

BARRIERS ADDRESSED / IMPLEMENTATION CHALLENGE

1. High investment.
2. Lack of awareness regarding solar thermal energy systems.

ASSESSMENT OF OVERALL PROJECT EFFECTIVENESS:

Installation of SWH Systems to cater various hot water reqirments of beverage industry is effective but capital intensive option. Considering high upfront capital cost, a step by step shit from furnace oil to SWH system was adopted by the organisation

successfully. 70% of the current expenditure on energy could be saved if SWH become major source of energy supplemented by furnace oil and electricity.

14.1.2 Greece – Dairy Industry

Location of Project	Thessaloniki, Greece
Year Project Implemented	2000
Name of Project Implementer	Centre for Renewable Energy Sources (User - Mega S.A. dairy)
Type of Project Implementer	National Public Entity
Industrial Segment Targeted	**Food Industry (Beverages)**
Project Objective	Reduce Fossil Fuel Consumption & Carbon Emission
Project Target	Low Temperature Preheating Application& Process Heating Application
Specific Technology Used	**Flute Plate Collector and Parabolic Concentrator**

DESCRIPTION OF THE PROJECT

Mevgal is the largest milk company of Northern Greece and the third largest producer of fresh dairy products in the Greece. Factory produces and sells under its brand name more than 170 products.

Steam is required in the various sections such as pasteurization, sterilization, evaporation, drying of the manucaturing process whereas hot water is required for the operation of the Cleaning in Place (CIP) machine of the factory, which is used to clean and disinfect the utensils and machinery of the factory. Originally, steam was provided by the steam boilers running on heavy oil, which were fed cold water from the water supply grid. The water requirement of the steam boilers was 150 m3/day.

The factory operates 24 hours a day, 7 days a week. It has around 800 employees. Its water consumption is 120-150 m3/day. Required temperature of process water is 20-80^{0}C for washing machines and 20-130^{0}C for other processes.

A large-scale solar thermal system for hot water was installed on the roof of the dairy. Total area of solar collectors is 727.2 m2, 403 m2 of which are selective flat plate collectors; 216 m2 - flat plate collectors and 108 m2 – compound parabolic concentrating (CPC) collectors all inclined on 45 degrees South. Technical Specifications of installed collerctor is provided below:

- Total area of solar collectors = 727.2 m2
- Collector's Area:

  a) 168 x 2.4 m2 = 403.2 m2 (selective flat plate collectors)

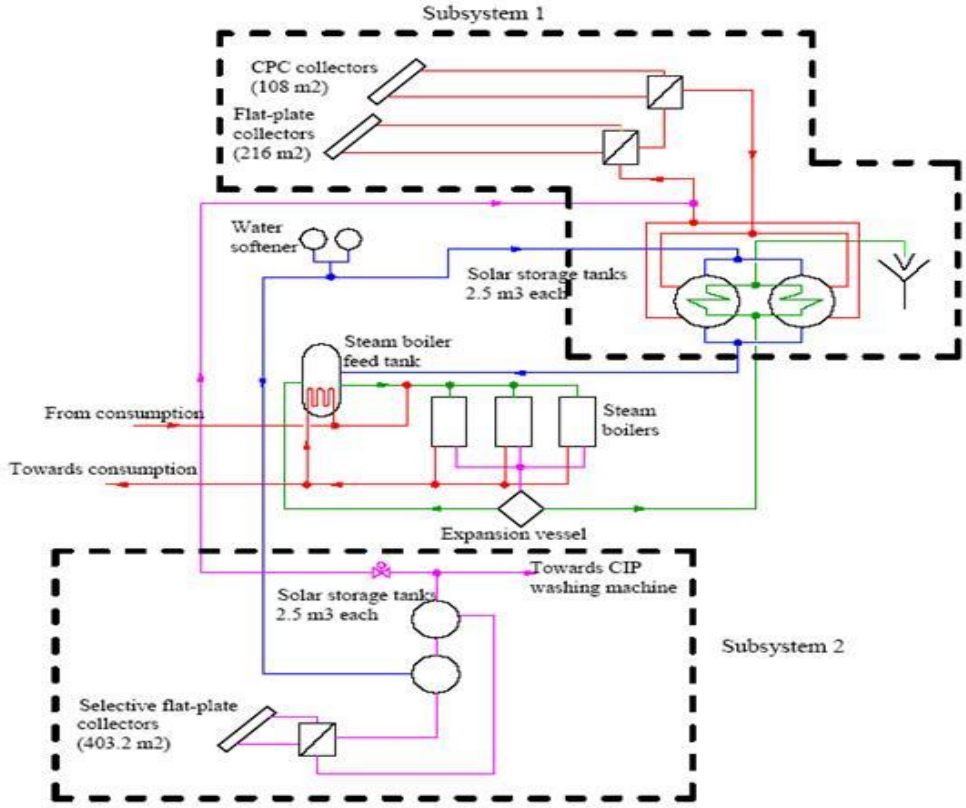
  b) 108 x 2m2 = 216 m2 (flat plate collectors)

  c) 40 x 2.7m2 = 108 m2 (CPC collectors)
- Inclination of flat plate collector: 45 Deg South
- Hydraulic circuit: closed loop water /propylene glycol
- Collector's field layout (selective FPC): 14 parallel branches with 12 collectors per branch
- Collector's field layout (CPC): 8 collectors connected in parallel
- Collector's field layout (FPC): 9 parallel branches with 12 collectors per branch
- Capacity of solar storage tanks: 2 x 2.5 m3 (in series) – selective collectors

  2 x 2.5 m3 (in parallel) – CPC + flat plate collectors

Water is heated in two 2,500 liters storage tanks through a heat exchanger and a closed-loop circuit communication with the solar collectors. The water is then used in the factory's washing machines and for preheating the water entering the steam boilers. The system's energy performance is of the order of 660 kWh/sq.m./year. The back-up heating is fulfilled by 3 heavy oil fired steam boilers (12 MW). Schematic of the same is provided in Figure 14.3 below:

Figure 14.3: Schematic of Built Solar Systems in Mevgal Dairy



The solar system presented in above Figure 14.3consists of two subsystems:

- Subsystems 1 depicted in Figure 14.1 consist of two primary closed circuits with water/ethylene glycol (20%) mixture. Primary circuit 1 has 216 m2 flat-plate collectors, which transfer their heat to the process water via heat exchanger 1 (94.6 kW capacity) and primary circuit 2 has 108 m2 Parabolic Concentrator (CPC)vacuum tube collectors, which transfer their heat to the process water via heat exchanger 2 (79.1 kW capacity). The heat exchangers are connected in series and the process water first enters heat exchanger 1 and then heat exchanger 2 before entering the two parallel 2.5 m3 storage tanks which are heated additionally by the steam boiler blow-down water. The solar collectors are located on the roof of the boiler room.

- Subsystem 2 depicted in Figure 14.1 consists of a primary closed circuit with a water/ethylene glycol (20%) mixture. Primary circuit 3 has 403.2 m2 selective flat-plate collectors, which transfer their heat to the process water via heat exchanger 3 (209.3 kW capacities). The hot water generated in the heat exchanger is fed to two in-series 2.5 m3 water storage tanks and is then fed to

the washing machine of the plant. When the washing machine is not in operation, the hot water is bypassed and fed to heat exchanger 1 of subsystem 1. The solar collectors are located on the roof of the cheese factory of the plant.

The system manufacturer was Intersolar S.A. Apart from installation of renewable energy sources at its factory; Mevgal has also demonstrated particular sensitivity to issues of environmental protection.

DETAILS OF SPECIFIC FINANCIAL ASSISTANCE

The investment in solar installation was undertaken jointly by the Centre for Renewable Energy Sources-CRES (72.5%) with a subsidy through the Operational Programme for Energy (OPE) for the promotion of energy efficiency, Mevgal S.A. (20%), and the Agricultural Bank of Greece (6.5%).

The installation was financed with a Third Party financing contract, whereby a Third Party (CRES) financed the installation of the system and Mevgal had no initial investment. Based on a private agreement between the two, CRES was responsible for monitoring, operation, and service and energy measurement of the system. Mevgal S.A. started with paying CRES a monthly rate for the amount of energy supplied by the system, which is monitored by CRES. Mevgal S.A. will own the system after paying back the initial investment with interest. Cost benefit analysis of installed SWHS is provided in the Table 14.3 below:

ECONOMICS OF SWHS	
Daily Hot Water Requirement, LPD	120000 to 150000
Water temperature requirement in process	80 oC
Average Inlet Water Temperature (co)	20 oC
Quantity of hot oil required per day, Kg	900
Quantity of Hot Oil required per annum, (@ 330 days per annum)	297000
Cost of the Hot Oil per annum (0.295 €/kg), €	€ 87615
Cost of the installed SWHS systems	€180000
Simple Payback Period, Years	2.05 Years

BARRIERS ADDRESSED / IMPLEMENTATION CHALLENGES:

- Increased amount of soot in the exhaust fumes of the steam boiler, resulting in deposition of soot on the collector surface reducing its efficiency;
- Loss of anit-freeze due to leakages occurred during frost

ASSESSMENT OF OVERALL PROJECT EFFECTIVENESS

The project initiated by CRES has been successful in replacing fossil fuel for water heating with SWH. The project is also an example of successful implementation of Third Party Financing or ESCO mode of financial assistance in the industrial sector. Today, the system is operational and in excellent working order.

14.1.3 Spain – Dairy Industry – 360 kW Solar Thermal Systems

Location of Project	Barcelona, Spain
Year Project Implemented	2005
Name of Project Implementer	CONTANK
Type of Project Implementer	Industry Owner
Industrial Segment Targeted	**Food Industry (Beverages)**
Project Objective	Reduce Fossil Fuel Consumption &to explore renewable energy sources for heating and cooling
Project Target Process Heating Application	
Specific Technology Used	Flat Plate Collector and Concentrating Solar Thermal Collector

DESCRIPTION OF THE PROJECT

The solar plant of Contank in Castellbisbal (Barcelona, Spain) started operation in March 2005. The Castellbisbal's parking service was a new building where the Concentrating Solar Thermal Collector (CSTC) was proposed at the design stage. Thus, the roof structure and the distance between the rafters have been set according to the weight and the size of solar collectors. In this facility liquid freight goods, transportation containers from trucks and railways are cleaned. Part of the cleaning process requires hot water vapour.

The solar plant, installed on the roof of the factory hall, provides heat gains of 429 MWh (841 kWh/m2) which covers 21% of the total hot water demand. The investment cost for the system is €268,000. The collector system was supplied by Sonnenkraft, Austria and engineered by Aiguasol Engineering, Barcelona. The estimated annual savings are €14,300 (at a cost for natural gas of 25 €/MWh). Taking into account the cost for operation and maintenance of about €1,250 /year, the net savings are about €13,050 /year. The installation has a monitoring system that allows detecting system incidences through internet.

The CSTS consists of 9 rows of solar collectors connected in parallel, where 4 of the rows have 8 collectors and 5 of the rows have 12 collectors, all connected in series.The row capacity is 910 l/h, summing up a total capacity of 8,189 l/h. The CSTS has one heat exchanger and a 40,000 litre solar storage tank. Its nominal solar thermal gradient is 36.6 K. Some technical details regarding the CSTC are as follows:

Type of collector = Flat Plate

Gross collector area = 570 m2

Aperture area of collectors = 510 m2

Thermal power = 357 kW $_{Therm}$

Orientation of collectors = South-East (-24°)

Inclination angle to horizon = 25°

Freezing protection = Primary Propenglycol 30 %

Overheating protection = Expansion vessel, safety valve

Buffer storage = 40 m^3 (one storage tank)

Hot tap water storage = 6 m^3 (2 × 3 m^3)

Auxiliary heater = Natural Gas steam boiler

DETAILS OF SPECIFIC FINANCIAL ASSISTANCE

Total subsidy of 37.9% by the Institute for Energy Diversification and Saving (IDAE) and the Catalonian Institute of Energy (ICAEN) along with tax reduction of 11.1% of the investment cost and a financing scheme with a low interest rate.

BARRIERS ADDRESSED / IMPLEMENTATION CHALLENGES:

- Non pressurised storage without expansion vessel was used leading to cost reduction.
- Cost was further reduced by using low flow system was used without compromising much on the efficiency.
- Low inclination of collectors i.e. 20^{o} lead to compromise on optimum output per unit
- area and optimum use of available roof space.
- Anti-legionella protection was provided by serial connection with auxiliary storage above 70 ^{o}C as well as chemical treatment.
- Light weight support structure made of aluminium was used.

14.1.4 Spain – Textile Industry

Location of Project	Spain
Year Project Implemented	2005-07
Name of Project Implementer	EMS Textile Project, Europe Intelligent Energy Executive Agency
Type of Project Implementer	**Europe Intelligent Energy Executive Agency, European Commission**
Industrial Segment Targeted	**Textile Industry**
Project Objective	Reduce Fossil Fuel Consumption & to develop demonstration project
Project Target Process Heating Application	
Specific Technology Used	Vacuum Tube Solar Collector

DESCRIPTION OF THE PROJECT

Textiles Mora S.A.L. is a large production company that manufactures and markets different product ranges related with household linen, bed blankets, multiuse blankets, sheets and quilt covers. The manufacturing process in a Textiles Mora industry consists of following sections:

- Spinning Section
- Yarn Warehouse
- Looms
- Estampacion (Embossing)

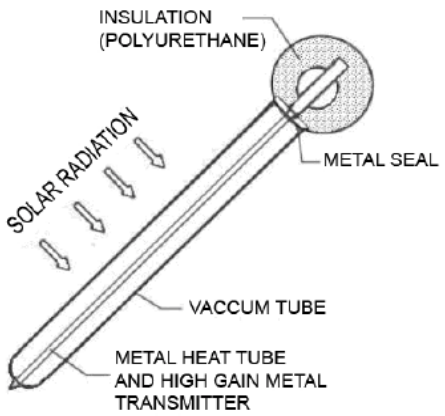
- Finishes
- Confectioning (Deying)
- Warehouse

Detailed Energy Audit of the facilities of Textile Mora was carried out with the objective of promoting energy management, reduce dependncy on natural gas and reduce expenditure on energy by adopting renewable energy sources. Energy Audit study showed that its total energy consumption is approximately 13.5 million KWh. Natural Gas is the energy used for water heating. The expenditure on Natural Gas exceeds the €230000/annum. Hot water at different temperature is required in the different section of the manubeing process such as washing (40 to 80 oC), belaching (60 to 100 oC) and dyeing (100 to 160 oC). Hot air is also required for drying the sludge.

This project was initiated with the objective of reducing the dependence on Natural Gas. The project has led to a reduction in the consumption of Natural Gas by the installation of solar collectors to heat water. Vacuum tube solar collectors were installed, due to the fact they are ideal for use in the temperature range 60^{o} to 90^{o} C, as without concentration they are the only type that can reach these temperatures and also offer the best quality-efficiency-price ratio.

These collectors are also tried and tested and manufacturers offer long guarantee periods, while the minimum maintenance involved has made them popular with consumers. With these collectors, the absorber is made of glass tubes from which the air has been removed to avoid heat loss due to conduction and convection, and within which are other absorbent elements that heat a liquid especially designed for this purpose. Different components of the Vacuum Tube Solar Collector is shown in the figure 14.4 below:

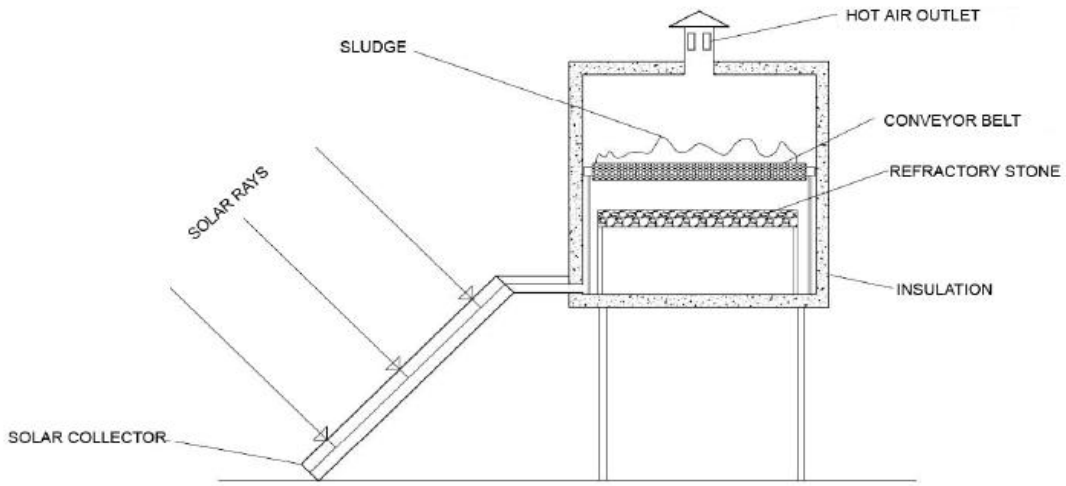
Figure14.4: Vacuum Tube Solar Collector



This type of vacuum collector is the only type capable of reaching relatively high temperatures needed for certain industrial processes or for heating using conventional radiators without concentration. Those used in the installation have an efficiency coefficient greater than 0.77 and a very low heat loss coefficient of less than 2.

The installation consists of 6,750 square metres of collector surface, with a tilt between 40º and 70º to ensure optimum performance and occupying a total of 4,500 square metres made up of roofs and areas next to walls.The industry at the time of project was generating 92,000 Kg per year of waste sludge. The sludge had 70% humidity factor which increased its weight considerably. A conveyer belt system was designed to dry them. In the future, the industry plans to use hot air for drying the sludge with the help of 45 m2 of solar collection system. Schematic of Solar based Hot Air System for Sludge drying is shown in Figure 14.5 below:

Figure14.5: Solar Assisted Hot Air System for Sludge Drying



Cost benefit analysis of installed SWHS for hot water generation is provided in the Table 14.4 below:

ECONOMICS OF SWHS	
Daily Hot Water Requirement, LPD	225000
Water temperature requirement in process	100 oC
Average Inlet Water Temperature (oC)	13.6 oC
Quantity of Natural Gas required per day, m3	176..27
Quantity of Natural Gas required per annum, (@ 26 days per month & 12 months per annum)	55138
Cost of the Natural Gas per annum (€ 2.85/m3), €	€157143
Cost of installation considering the Grant, €	€ 945000
Simple Payback Period with Grant, Years	6.00 Years

BARRIERS ADDRESSED / IMPLEMENTATION CHALLENGES

- High upfront cost;
- Textile industries in Spain depend mostly on natural gas for heating which is costly;
- Many industries in European Union have already undertaken energy efficiency investments, but the improvement of energy management is not among their priorities, in many cases because they are not aware of its benefits and practices.
- Lack of adequate financial and human resources in the industry for successful implementation of energy management.
- Financial assistance in the form of grants, financial incentives and third party financing not available.
- Lack of stringent legislation to adopt energy efficient practices.

14.1.5 Greece – Installation of SWHS for Industrial Processes

With respect to industrial application for solar water heater, five main industrial sectors can be distinguished, promising good acceptance of large solar thermal

systems. These are industries with relatively low energy consumption, where the fraction of energy provided by the solar thermal system to the industry's energy load can be quite significant. Solar thermal systems are particularly effective in industries that require water temperature in the range 40–80°C. Five industries with good potential applications of solar thermal systems are:

1. Food industry (dairy products, cold cut and process meat factories, pastry and cake confectioneries, olive oil refineries, tinned goods, slaughterhouses).
2. Agro-industries (solar drying, horticulture–nursery greenhouses, slaughterhouses, meat processing, livestock landings).
3. Textiles (tanneries, leather treatment, cloth, refineries, textile treatment workshops).
4. Chemical industry (cosmetics, detergents, pharmaceuticals, wax, distilleries, breweries).
5. Beverage industry (wineries, liquor and wine distilleries, breweries, soft drinks).

Several successful demonstration projects have been carried out at to enhance penetration level of solar thermal systems in the industrial sector. The most well known is 'Solar Village' close to Athens, built in 1987 and reliably operating since then, with 435 dwellings and approximately 1,700 inhabitants, featuring several solar systems for hot water production and space heating, cogeneration, heat pumps etc. There are also several demonstration projects for process heating in the dairy, wine, textile dyeing/finishing, rice drying and tannery industry. Some of them (Achaia Clauss Winery, MEVGAL diary, etc) were installed on a guaranteed performance base. Use of solar water heaters in the Greek industrial sector has been majorly restricted to demonstration projects. In recent years a big demonstration project for solar cooling was erected in the Sarantis S.A. cosmetic industrial complex close to Athens. Few examples from the application of solar water heaters in the industrial sector have been briefly described below:

14.1.6 Achaia Clauss S.A.

Achaia Clauss S.A. is a winery situated on the outskirts of the city of Patras. Its main industrial activity is the production of red, white and rose wine. Hot water (60–75°C) is required for the washing and sterilisation of the bottles in the bottling factory. The hot water consumption of the bottling process is 100 m3/day. Originally, the hot water was provided by a steam boiler running on diesel fuel, which heated the water in two

parallel, horizontal, 3000 l storage tanks (via a submerged heat exchanger) located in the boiler room of the plant according to the needs of the bottling process.

The solar system was installed in 1993 and consists of: 308 m2 sandwich-type, flat plate collectors coated with black paint located on the roof of the winery; closed-loop primary circuit with an open expansion vessel and two parallel, horizontal, 3000 l, closed solar storage tanks located on the roof of the winery. The water heated by the solar collectors circulates in a closed loop and heats the water in the solar storage tanks via submerged heat exchangers. Anti-freeze protection is provided in the closed loop on very cold winter days by activating the pump and circulating the water when the temperature drops below 5°C. The hot water leaving the solar storage tanks is fed to the two original storage tanks where auxiliary heating of the water is provided by the steam boiler. A re-circulation branch has been included which consists of a hydraulic branch connecting the solar storage tanks with the original storage tanks. When the water in the solar storage tanks exceeds the temperature of the water in the original storage tanks a pump is activated, which circulates the hot water from the solar to the original storage tanks. In this way, hot water produced by the solar collectors during the hours that the factory is not operating is utilised and energy is saved in the early hours of operation of the plant as the auxiliary heat required from the steam boiler is reduced.

The system operated for 6 years yielding a mean performance of 300 kWh/year/m2. Due to administrative and financial difficulties of the company, the necessary maintenance work on the system was not carried out and this inevitably led to corrosion problems and inefficient operation of the system. Today, the system has been shut down due to the severe corrosion problems encountered by the system (25% of the collectors have either cracked glass covers or deformation of the plastic collector frame or rusting of the absorber plates). According to the monitoring results, a large amount of heat was lost from the solar storage tanks during the night hours due to poor insulation of the tanks. Also, due to this fact, the impact of the re-circulation branch was minimal.

The installation was financed with a Guaranteed Solar Results (GSR) contract, whereby the user paid no money for the installation of the system, but paid the manufacturer the amount of energy supplied by the system on a monthly rate, based on a fixed rate per kWh decided upon before the installation of the system. A third,

independent party, in this case the Centre for Renewable Energy Sources (CRES) undertook the monitoring of the system, which determined the energy supplied by the system. When the user paid the initial investment of the system back, the system became the exclusive property of the user.

14.1.7 Allegro S.A.

Allegro S.A. is children's clothing industry situated in the municipality of Metamorfosis, in the city of Athens. Its main industrial activity is the processing of imported children's clothing (washing, ironing, sorting and folding). Hot water (40–90°C) is required for the washing machine of the factory. The hot water consumption of the washing process is 0.7 m3/day. Also, the steam presses of the factory require steam for ironing the clothes. Originally, steam was provided by a steam boiler running on diesel fuel, which was fed cold water from a 500-l storage tank located in the boiler room of the factory. The water requirements of the steam boiler are 1.4 m3/day.

The solar system was installed in 1993 and consists of the following items: 55 m2 sandwich-type, flat plate collectors coated with black paint, located on the roof of the factory; closed-loop primary circuit with an open expansion vessel and one horizontal, 1500 l, open solar storage tank located on the roof of the factory. The water heated by the solar collectors circulates in a closed loop and heats the water in the solar storage tanks via a submerged heat exchanger. Anti-freeze protection is provided for in the closed loop on very cold winter days by activating the pump and circulating the water when the temperature drops below 5°C. The hot water leaving the solar storage tanks is fed either to the washing machine of the factory where the auxiliary heating of the water is provided for by an internal electric resistance or to the original storage tank feeding the steam boiler. In this way, the solar system preheats the water entering the steam boiler.

Today, the system is operational although the lack of necessary maintenance to the system has resulted in minor corrosion problems and reduced efficiency of the system (10% of the collectors have either cracked glass covers or deformation of the plastic collector frame or rusting of the absorber plates). During the first years of operation of the system, the open solar storage tank encountered severe corrosion problems and was replaced by a closed, vertical tank with a closed expansion vessel.

14.1.8 Sarantis S.A.

Sarantis S.A. is a cosmetics industry situated on the outskirts of the city of Inofita. Its main industrial activity is the production and trade of cosmetics products. The solar system is used for the space cooling of the stock warehouse of the factory. The temperature of the warehouse must be 27°C and this is maintained by silica gel adsorption chillers located in the boiler room of the factory. Water source chillers located on the roof of the boiler room provide for any auxiliary cooling.

The solar system was installed in 1999 and consists of the following items: 2700 m2 tube-fin, flat plate collectors with a selective paint coating, located on an area especially set aside for the collectors; closed-loop primary circuit with a closed expansion vessel and one horizontal, 2000 l, closed solar storage tank acting as a buffer for the start-up of the adsorption chillers located in the boiler room of the factory. The water heated by the solar collectors circulates in a water–glycol closed loop and is fed to the regeneration chamber of the adsorption chillers.

The operational results of the system are not available. The system was funded with a GSR contract, whereby the manufacturer guarantees a minimal performance of the system otherwise he does not receive the full amount due to him.

14.1.9 Alpino S.A.

Alpino S.A. is a dairy situated on the outskirts of the city of Thessaloniki. Its main industrial activity is the production of dairy products (butter, cheese, butter milk, etc.). Steam is required by the various dairy processes of the plant (pasteurisation, sterilisation, evaporation and drying) and for the operation of the Cleaning in Place (CIP) machine of the factory, which is used to clean and disinfect the utensils and machinery of the factory. Originally, steam was provided for by three steam boilers running on heavy oil, which were fed cold water from the water supply grid. The water requirements of the steam boiler are 40 m3/day.

The solar system was installed in 2000 and consists of the following items: one collector branch with 324 m2 tube-fin, flat plate collectors coated with black paint, located on the roof of the factory; closed-loop primary circuit with a closed expansion vessel and one vertical, 15,000 l, closed solar storage tank located in the boiler room of the factory. The water heated by the solar collectors circulates in a water–glycol closed

loop and heats the water in the solar storage tanks via submerged heat exchangers. There is also a second collector branch with 252 m2 tube-fin, flat plate collectors coated with black paint, located on the roof of an adjacent building; closed loop primary circuit with a closed expansion vessel and one vertical, 10,000 l, closed solar storage tank located in the boiler room of the factory. The water heated by the solar collectors circulates in a water–glycol closed loop and heats the water in the solar storage tanks via a submerged heat exchanger. The hot water produced by both branches of the solar system is used to pre-heat the water entering the steam boilers of the factory.

The operational results for the system are not available. The system was funded with a Guaranteed Solar Results (GSR) contract.

Barriers to Growth of SWH in Greece

The main competitor of the solar water heater is the electric heater. In the last decade, the electricity cost in Greece decreased in real terms by 28%. Additionally, the VAT for electrical energy and gas is set to 8%, whereas the VAT for solar systems is 18%. This has lead to a decisive loss of competitiveness for solar water heaters. Moreover, solar thermal systems have high upfront cost and with current technology, financial payback times are often beyond commercial requirements.

There is lack of technology in the market. Many industrial processes require higher temperatures than the typical solar thermal applications (domestic hot water, space heating, swimming pool heating). New designs, sometimes new materials, are needed to cater for these higher temperature demands which are not available and require further research.

The low price of fuel oil, combined with a lack of subsidies, make solar systems in the industrial sector, solar space heating and cooling, etc., not financially attractive. Hence adoption in the industrial sector is limited. Furthermore, for industrial and commercial applications of solar systems grants ranging from 30%-40% to support investments are available only for certain time period based on government policies and not on a constant basis. Third party financing has been used only for pilot projects. Currently there are no financial incentive schemes for solar systems. Especially in the commercial sector, and for applications like solar assisted cooling, financial support is essential in creating a sustainable market. In Greece, in the absence of subsidies, solar energy is conditionally feasible only for domestic water heating. Without funding

from national or EU sources, the spread of solar thermal systems cannot increase significantly.

The profit margins of the manufacturers are not high enough to finance a marketing campaign and marketing budgets are low. Hence, there has been no important 'technical innovation' or new marketing method introduced.

The number of solar thermal installations for industrial processes is very small. This is a key barrier to the broad adoption of solar heat systems in industries. Specific awareness raising campaigns targeted at decision makers in the industries most suitable for solar thermal process heat, e.g. food and textile industry must be adopted.

14.1.10 Lessons learnt from the International Experience

It was observed that various projects targeting pre heating application (boiler make up water), process heating applications and hot air requirement for the drying applications implemented in the various industrial sectors such as Textiles, Dairy, Food Industry etc. These projects were successful in reducing their partial thermal energy requirement for the abovementioned applications. In India also, industrial sector such as Textile Processing, Pulp & Paper, Dairy, Food Processing, Chemicals, etcprovide immense opportunity to generate hot water through installation of SWH systems for various preheating and process heating applications. However, the penetration of solar water heating systems in the Industrial sector is very limited and scattered. In order to increase the awareness and penetration in the industrial sectors, MNRE may consider developing demonstration projects targeting the abovementioned sectors.

It was also observed that some of the projects considered integration of solar water heating systems to meet their hot water requirement during its design stage only. Applications like space cooling and process cooling based on the SWH systems also provide the immense opportunity in the different industrial sectors. However, it is not economical to implement the same in the existing premises considering the factors like space constraint, higher capital cost etc. However, same project may become economically feasible if considered during the design stage only. In India, various industries such as Dairy, Pharmaceutical etc. require chilled water for the process cooling and comfort cooling purpose. However, very few projects based on the SWHS

have been implemented in order to meet the process and comfort cooling requirement. Solar based process cooling and comfort cooling will provide the immense potential for the existing industrial set up or industrial set up which are planning for the expansion / development of new set up at existing/different location.

It was also observed that higher upfront cost of solar thermal systems resulted in longer payback period, which is beyond the commercial requirement. In order to address the issue of the high capital investment, some of the projects also utilised the services of Energy Service Companies (ESCO) for the successful implementation of the projects on the shared saving basis. In India, higher upfront cost is one of the critical barriers for the less penetration of the solar water heating systems in the industrial sectors. Also, ESCO business in India is also at the nascent stage. It is important that MNRE initiates the process of accreditation of Energy Service Companies which can take up the various renewable energy projects on shared savings or guaranteed savings mode in the different consumer categories.

14.2 Annexure-II- National Case Studies

It can be seen from the case studies presented in the earlier section that Solar Water Heating Systems have been implemented for the variety of applications in the different industrial sectors in different parts of world. However, diffusion of Solar Water Heating Systems in the Industrial Sector in India is limited and scattered. Industrial sectors such as Textile, Food Processing Industries, Pharmaceutical Industries, and Auto Component Industries etc. require hot water at different stages in their processes. Hence, it is necessary and important to gather details of projects implemented by the various Industrial units in India and to identify the barriers, which hamper the penetration of SWH systems in the Industrial sectors. With the help of various primary and secondary sources, ABPS Infra has identified a few SWH projects implemented in the different industrial sectors. Based on the information collected, ABPS Infra has prepared eightdetailed case studies on SWHS implemented in the different industrial sectors such as Pharmaceutical, Textile, Food Processing and Chemical Industries etc. Each of these case studies is described in the subsequent section:

14.2.1 Maharashtra – Pharmaceutical Industry

Location of Project	Dahanu, District Thane, Maharashtra
Year Project Implemented	2006
Name of Project Implementer	Associated Capsules Pvt.Ltd.
Type of Project Implementer	Industry Owner
Industrial Segment Targeted	**Pharmaceutical Industry**
Project Objective	Reduce Electricity Consumption for hot water generation
Project Target	Low Temperature (60 °C) hot water for rinsing capsules
Specific Technology Used	**Flat Plate Collector (Pumped flow)**

DESCRIPTION OF THE PROJECT

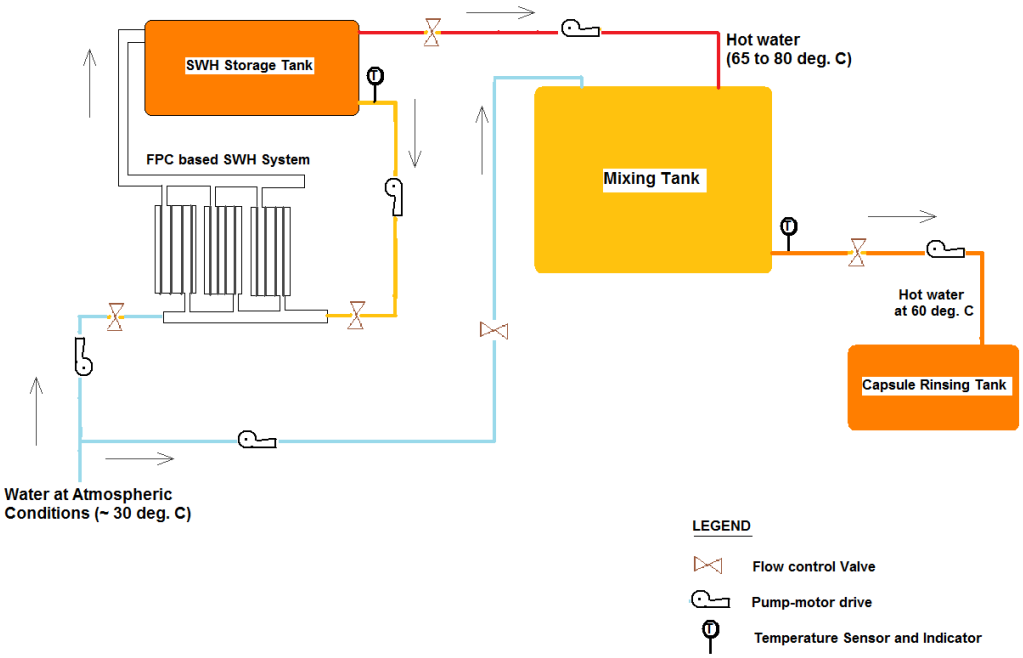
M/S Associated Capsules Pvt Ltd (ASPL) is one of the world's largest producers of empty hard gelatin capsules, with the company's three plants at Mumbai, Dahanu and Shirwal, providing service to about 1000 customers worldwide. The entire range of capsule sizes are manufactured, including special features such as four color printing.

The company is known for precision in manufacturing, intensive in-process controls reinforced by rigorous statistical techniques and analysis.

Hot water at around 60 deg C was required to rinse the Capsules in the plant. Electric Hetars were used for heating the water up to desired temeperatures. ASPL with the objective of reducing the dependence on Electricity, initiated a project of installatioin of Solar Water Heating System for generation of hot water. The sizing of SWH system capacity was done by considering the hot water requirement during the day. This total requirement had been calculated by metering the usage of hot water and use of energy meter to measure consumption of electricity required for heater to generate hot water. It was estimated that around 50,000 LPD hot water is required at around 60^0C which consumed approximately around 2736 units per day.

In order to reduce the dependence on Electricity, ASPL installed the flat plate based SWH system of 50,000 LPD capacity in the year 2006. SWH system installed is highly automated and has many control features for performance monitroing and fault identification. Schematic of the SWH system installed at Dahanu Plant is presented in below figure:

Figure 14.6: Schematic Layout of FPC SWH system used inDahanuPlant



The SWH system is installed on the terrace of the main building. The collectors are mounted on a MS fabricated platform. The inlet, system and outlet piping has been done in stainless steel due to requirement of the process of cleaning of capsules. The signals from the temperature sensors are fed to the controller which further controls the ON/OFF operation of pumps and flow control valves to regulate the quantity of hot and cold water.

Operation of the System:

- The temperature of water heated by SWH system is in the range of 65 to 80^0C. But the process requirement of 60^0C water is met by integrating automated temperature control and using a combination of open and closed loop forced flow systems.
- By the end of the day, the hot water storage tank of SWH system gets filled up. Once the maximum level is reached in this hot water tank, the level sensor provided in the tank level tube stops operation of the pump motor provided in the open loop system.
- Once the open loop (Primary system) stops functioning, the operation of closed loop (Secondary system) starts.
- The closed loop is operated through differential temperature controller and is in operation till the level or the temperature in the tank drops below the designated point.
- The necessary indication of each function and component in operation are provided at suitable places on the control panel box. This helps in identification of faults and monitoring the system performance.

Table 14.5: Cost benefit analysis of FPC based SWH System

ECONOMICS OF SWHS	
Amount of energy required to heat (M) 50,000 liters of water per day upto(T_1) 65 °C with (T_2) 25 °C average inlet Water Temp.	M X Cp X (T_1-T_2) = 20,00,000 K Cals
Existing Fuel Consumption Rate Per Day (FC) Fuel Type :**Electricity**	2736 kWh of Electricity / Day
FuelCostSaved Per Annum for (D)**300**days of SWHS working per annum @ (C) Rs. 5**/-**Unit of Fuel	A = FC X D X C =**Rs. 41.04lacs**
Cost of SWHS & Other Associated Costs (C_{swh})	**Rs. 62.82lacs**
Amount saved in 1st Year In terms of energy Saving	A = **Rs. 41.04lacs**
In terms of 80% depreciation benefit in 1st Year under	B = Cswh X 30% X 0.8 =

Income Tax Act (30% tax saving)	**Rs. 15.076lacs**
Capital Subsidy (@437 collector &Rs. 1650/collector)	**Rs. 721050**
Payback Period (Without Depreciation)	**1.36 years**
Payback Period (With Depreciation)	**0.98 years**

ASSESSMENT OF OVERALL PROJECT EFFECTIVENESS:

For last more than four years the SWH systemis in use for everyday operations of the plant and the ACPL is satisfied with the consistant performance delivered by the SWH system installed by M/S Bipin Engineers Pvt Ltd.

14.2.2 Himachal Pradesh – Fast Moving Consumer Goods

Location of Project	Barotiwala, Himachal Pradesh
Year Project Implemented	2010
Name of Project Implementer	Hindusthan Unilever Ltd.
Type of Project Implementer	Industry Owner
Industrial Segment Targeted	Fast Moving Consumer Goods
Project Objective	Reduce Electricity Consumption for hot water generation
Project Target	Hot water for Colour batch making process
Specific Technology Used	Evacuated Tube Collector

DESCRIPTION OF THE PROJECT

Hindusthan Unilever Ltd (HUL) is one of the largest producers of fast moving consumer goods in India with a large capacity production unit in Himachal pradesh at Barotiwala.

The soap manufacturing unit in this plant requires hot water at around 80 to 85°C in its perfume room. For years, 500 LPD of hot water was being produced using electric heater. In 2010, the soap unit at Barotiwala plant was integrated with electically assisted Evacuated Tube Collector (ETC) based SWH system to save annual consumption of 19,000 kWh of electricity. This SWH system is installed on the roof top of the soap production unit. The installation was carried out by M/s Neutech Solar Systems Pvt. Ltd. (Bangalore) and Synergy Solar Pvt. Ltd. (Chandigarh). Schematic of

Original electrical heating systems and newly electrical assisted SWH systems are presented in the below figures:

Figure 14.7: Initial Electrical Water Heating System

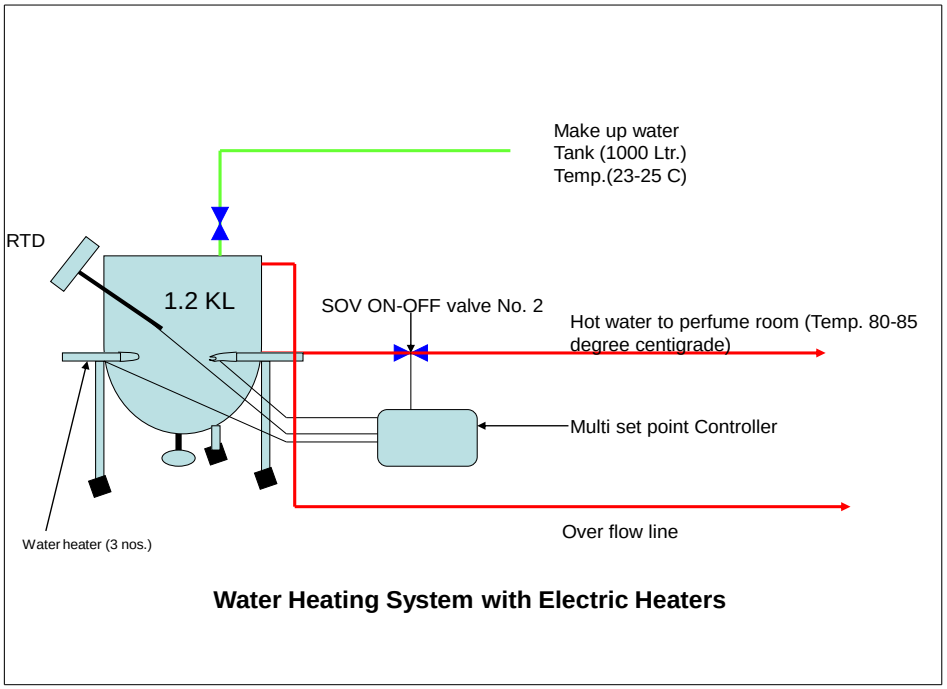
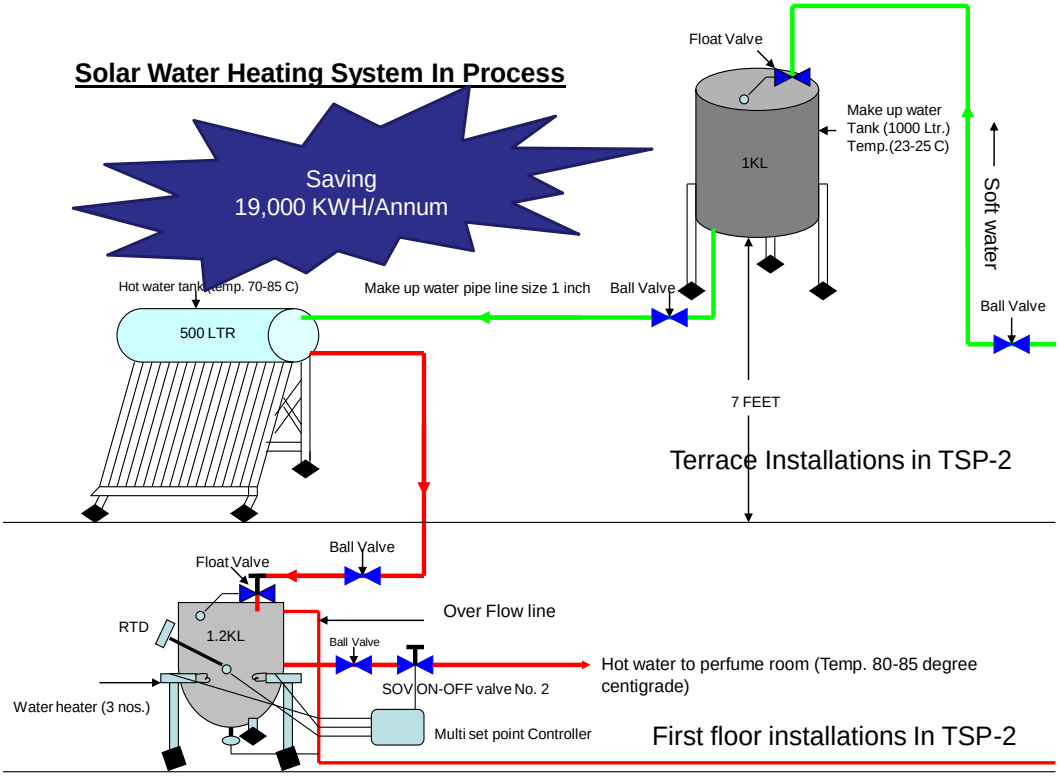


Figure 14.8: New Electrically Assisted Solar Water Heating System



Technical specifications of electrical assisted Evacuated Tube Collector based SWH system are presented in the table below:

Table 14.6: Technical Specifications of Electrically Assisted ETC SWH System

SWH System		
1	Capacity	500 LPD
2	No. of ETCs	90
3	Inner Tank Material	Stainless steel
4	Outer cladding	Aluminium sheet
5	Outer cladding finish	Glass wool/Rock wool
6	Hot water tank insulation density	48 kg/cm3
7	Hot water circulation	Thermo Siphoning
8	Back up provision during monsoon	Electrical heaters
9	Minimum water temperature at the outlet of SWH system	65 deg.C.
10	Maximum water temperature at the outlet of SWH system	85 deg.C.
11	Water pipe line size	1 inch
Auxiliary System (Electrical assisted back up for monsoon)		
1	No. of back up electrical heaters	3 no.s of 3 kW each
2	RTD	2 nos.
3	Water level indicator	1 no.
4	Capcity of Auxiliary tank	1200 litre
Multi set point controller system for operation of back up electrical heaters		
1	Electrical heater no. 3 is switched on	Temperature of water in auxiliary tank is less than 75 deg.C.
2	Electrical heater no. 2 is switched on	Temperature of water in auxiliary tank is less than 80 deg.C.
3	Electrical heater no. 1 is switched on	Temperature of water in auxiliary tank is less than 85 deg.C.

For this installation HUL did not avail the government subsidy due to the lengthy and cumbersome process of availing subsidy. Even without subsidy the SWH system had

simple payback period of about 2 years, by taking the benefit of only accelerated depreciation. The cost-benefit analysis has been shown in the table below.

Table 14.7: Cost benefit analysis of ETC based SWH System

ECONOMICS OF SWHS	
Amount of Heat required to heat (M) 500ltrs of water per day upto(T_1) 85 °C with (T_2) 30 °C average inlet Water Temp.	M X (T_1-T_2) = 27500 K Cals
Existing Fuel Consumption Rate Per Day (FC) Fuel Type: electric heater	172 KW Unit of Fuel / Day
FuelCostSaved Per Annum for (D)350days of SWHS working per annum @ (C) Rs. 5 / Unit of Fuel	A = FC X D X C =Rs. 3.01 lacs
Cost of SWHS & Other Associated Costs (C_{swh})	Rs. 1.70 lacs
Amount saved in 1st Year In terms of energy Saving	A = Rs 0.95 Lacs
In terms of 80% depreciation benefit in 1st Year under Income Tax Act (30% tax saving)	B = A X 30% X 0.8 = Rs. 0.228lacs
Investment Recovery in 1st Year (A+B)	Rs. 1.178 lacs
Net Investment = Total Cost – Saving in 1st Year (C_{swh} – (A+B))	Rs. 0.883 lacs
Pay Back Period of System	2 Years

ASSESSMENT OF OVERALL PROJECT EFFECTIVENESS:

The installed SWH systems has been in use for day to day operations and HUL is satisfied with the consistant performance delivered by the ETC SWH system. However, they have a concern that during the monsoon the SWH system does not provide water hot enough for desired application. Also the space requirement of the SWH installtion is another matter of their concern.

14.2.3 Gujarat – Chemical Industry

Location of Project	Vadodara, Gujarat
Year Project Implemented	2010
Name of Project Implementer	SudChemie India Private Limited
Type of Project Implementer	Industry Owner
Industrial Segment Targeted	**Chemical Industry**
Project Objective	Reduce Fossil Fuel Consumption for hot water generation

Project Target	Low Temperature (75 °C) water preheating
Specific Technology Used	**Parabolic Concentrator**

DESCRIPTION OF THE PROJECT

Sud - ChemieIndiaPvt. Ltd. (Sud - Chemie) is a subsidiary of Sud - Chemie AG, Germany and manufactures a wide range of catalysts for varied applications in Fertiliser Industries, Refineries, Petrochemical Industries, and Sponge Iron Industries. Recently, Sud-Chemie has started manufacturing catalysts for emission control in automobiles and stationary engines. These products are result of many years of research and development, which is an ongoing process for improvement of quality of the products. The products of SudChemie are sold in the domestic as well as in international market, with export to countries in Europe, America, Iran, Libya, Japan and Indonesia contributing 50% of the turnover. Sud - Chemie has two units in India; located at Nandesari in Gujarat and Cochin in Kerala. The Nandesari unit situated near Vadodara in Gujarat was established in 1978. The Unit manufactures wide range of catalysts using state–of-the art technologies. A well-equipped Quality Assurance laboratory and an R&D division carrying out research on some speciality areas are also functional at Nandesari.

SudChemie utilise both types of energy such as electrical and thermal energy to meet its energy requirement in the manufacturing process. Natural gas is being utilised for the purpose of production of heat required during the manufacturing process. Hot water at around 75°C is required in filter press section of the manufacturing plant. Total hot water requirement is around 72 m3/day (@18 m3/batch and around 4 batch/day) and consume natural gas of around 376 SQM/day. In order to reduce quantity of natural gas required for hot water generation, SudChemie decided to install SWH systems for the generation of hot water. SudChemie contacted several suppliers in order to calculate space requirement for the installation of SWH system with the capacity of 72 m3/day. Considering the space availability, SudChemie decided to install SWH system with 30m3/day capacity. SudChemie also decided to install Scheffler type parabolic concentrator instead of flat plate collector as later almost need double the space compared to parabolic concentrator. Twenty five Parabolic Concentratorseach having area of 16M²have been installed by Sud-Chemie.

The solar steam generation plant consists of solar parabolic concentrator, circular receiver, automatic tracking system, valves and control etc. The main component of the system is the 16 Sq. M. Solar parabolic concentrator, which concentrates the sun light in to approximately 45 cm, where the high temperature of around 500°C is generated. This high temperature heats the water circulating in the receiver by means of heat exchanger between the metal to water. Thus solar energy is directly converted into hot water, which is being pumped through the receiver. The heavy metal receiver is used as temperature reservoir. The solar parabolic concentrators are tracked automatically with the help of photovoltaic panel, light sensor, DC drive, gear motor etc. but focus is always on the point of receiver. Installation of this system resulted in to the savings of 156 scm/day of natural gas. Detailed cost benefit analysis is presented in the below table:

Basis	Unit	Value
BASIC DETAILS		
Temperature requirement in filter press	deg.C.	75
Quantity of Hot Water Required	M3/day	30
Heat Requird to heat the 30 m3/day of water	Kcal	1410000
Quantity of Natural Gas Required (@9000 kcal/scm)	Scm/day	156
Cost of Natural Gas (2Rs. 21/scm)	Rs/day	3276
Net Energy Savings Per Annum (@ 320 days/annum)	Rs./Annum	10,48,320/-
Depreciation firs year	%	80
Tax Savings on Depreciation	%	33
Total Project Cost of the SWHs system	Rs.	53,00,000
Payback Period Calculation		
Working for the First Year		
Total Project Cost	Rs	53,00,000
Tax Savings in the first year	Rs.	13,99,200
Subsidy from the Government	Rs.	14,00,000
Energy Savings in the first year	Rs.	10,48,320
Unabsorbed Investment after first year	**Rs.**	**14,52,480**
Working for Second Year		

Unabsorbed Investment after second year	Rs.	14,52,480
Tax Savings in the second year	Rs.	3,49,800
Energy Savins in the second year	Rs.	10,48,320
Unabsorbed investment after second year	**Rs.**	**54,360**
Simple Payback Period is two years and eighteen days only		

ASSESSMENT OF OVERALL PROJECT EFFECTIVENESS:

Fuels like natural gas and HSD are becoming costlier as well as scarce with the passage of time. As a part of the corporate social responsibility, Sud Chemie also carried out computation of carbon footprint of the manufacturing facility located at vadodara in Gujarat in the past. In order to reduce their carbon footprint as well as fossil fuel consumption, they have explored various renewable energy options and installed wind mill and solar water heating system. Sud Chemie has installed solar water heating systems which has been in use for day to day operations and helped in reducing natural gas requirement successfully. Sud Chemie only able to redue their natural gas consumption required for hot water generationonly partially due to space constraint.

14.2.4 Punjab – Pharmaceutical Industry

Location of Project	Toansa, Punjab
Year Project Implemented	2009
Name of Project Implementer	DSM Anti-infectives India Limited
Type of Project Implementer	Industry Owner
Industrial Segment Targeted	**Pharmaceutical Industry**
Project Objective	Reduce Fossil Fuel Consumption for hot water
Project Target	Low Temperature (75 °C) water preheating
Specific Technology Used	**ETC (Thermo Siphon SWH System)**

DESCRIPTION OF THE PROJECT

DSM Anti-Infectives (DSM) is a Dutch multinational company which is the world's leading supplier of active pharmaceutical ingredients which are most widely used in broad spectrum antibiotics for combating bacterial infections. Unlike other facilities around the world, its Punjab facility also manufacturers some of the key ingradients for antibiotics. SWH system with 150 ETC collectors has been installed last year for the

application of boiler feed water, which has reduced DSM's electricity consumption. The system also has integrated digital energy meters and temperature and pressure gauges and valves to indicate and monitor the perfomance variables.

Figure 14.9: Constructional Details of ETC system used in DSM project

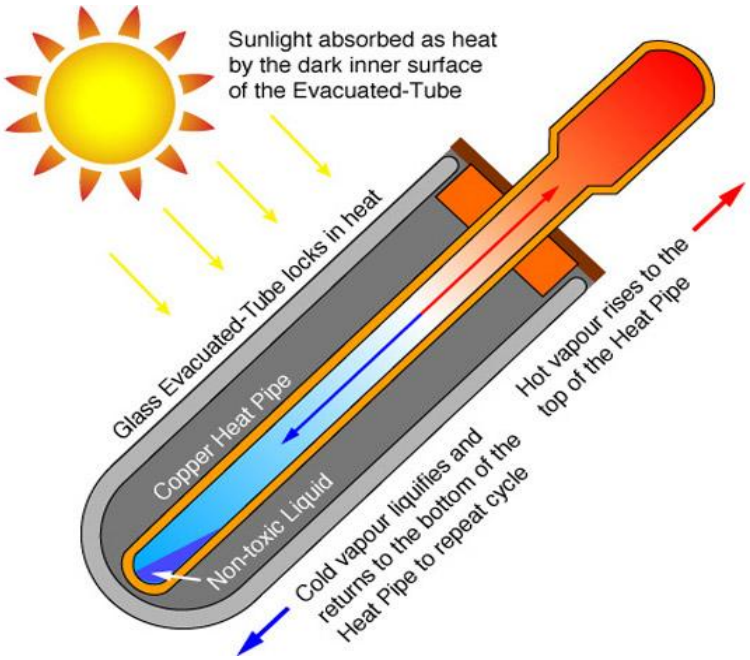


Figure 14.10: Perfomance Variables in ETC SWH system in DSM project

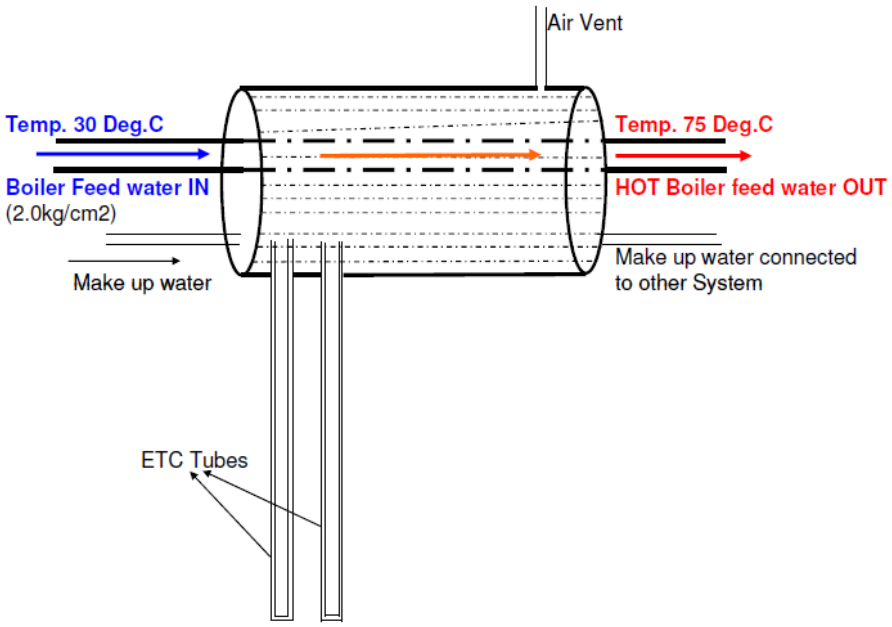


Table 14.8ETC SWH system performance parameters:

Sr. No.	Parameter	Value
1	Number of ETC Solar collectors	150
2	System Capacity	30,000 LPD
3	Avaialbility of Solar energy	330 days/annum
4	Hot Water Temperature	75°C
5	Energy Saving	1.5 TJ
6	Monetory Saving	Rs. 11.2 Lac per annum

Table 14.9: Cost benefit analysis of ETC based SWH System

ECONOMICS OF SWHS	
Quantum of annual saving in electricity as quoted by the DSM Dis-infectives	1.5 TJ (4,16,667 kWh)
Annual saving of electricity cost	Rs. 11.20 Lac
Cost of ETC SWH System of 30,000 LPD	Rs. 38 Lac
Simple payback period considering the following benefits • Accelerated Depreciation (of 80%) • Capital Subsidy (Rs 1650 per collector X 150 collectors)	Rs. 9.12 Lac Rs. 2.47 Lac
Recovery in first year considering the cost of electricity saved and accelerated depreciation (without subsidy)	Rs. 20.32 Lac
Simple payback period with Accelerated depreciation and Govt. subsidy	1.75 Years
Simple payback period with Accelerated depreciation and without any Govt. subsidy	1.87 Years

ASSESSMENT OF OVERALL PROJECT EFFECTIVENESS:

The awareness effort taken up by the SWH installer about the potential savings has been found to be motivating factor behind shift to solar energy based heating. This DSM plant in Punjab which has integrated ETC based SWH system for reduction in its electricity consumption has won the DSM Global Energy Network's award for year 2009 for achieving abovementioned saving.

14.2.5 Himachal Pradesh – FMCG – Canteen Applications

Location of Project	Barotiwala, Himachal Pradesh
Year Project Implemented	2010
Name of Project Implementer	Hindusthan Unilever Ltd.
Type of Project Implementer	Industry Owner
Industrial Segment Targeted	Fast Moving Consumer Goods
Project Objective	Reduce LPG Consumption for hot water
Project Target	Hot water for Canteen use (washing utensils)
Specific Technology Used	Evacuated Tube Collector

DESCRIPTION OF THE PROJECT

Hindusthan Unilever Ltd (HUL) is one of the largest producers of fast moving consumer goods in India with a large capacity production unit in Himachal pradesh at Barotiwala. To maintain the hygein of the canteen utensils and dishes, this plant has a practice of using hot water for cleaning and washing. For years, 800 LPD of hot water was being produced using LPG. In the year 2010, the canteen at Barotiwala plant installed Evacuated Tube collector based SWHS to replace the daily usage of about 6.5 kg of LPG.

Determination of SWH System Size (Capacity in LPD and Collector Area):

- The sizing of the SWH system capacity was done taking into consideration the requirement of hot water during the day.
- This total requirement had been calculated by metering the usage of hot water and use of LPG required to generate hot water.
- The SWH system daily delivers 800 litres of hot water at 60 to 75°C.

The SWH system is installed on the terrace of the canteen building. The installation was carried out by M/s Neutech Solar Systems Pvt. Ltd. (Bangalore) and Synergy Solar Pvt. Ltd. (Chandigarh). For this installation HUL did not avail the government subsidy due to lengthy and cumbersome process. Even without subsidy the SWH system offered the simple payback period of less than 5 years, by taking the benefit of only accelerated depreciation. Further the comparison of simple payback period with and without Government subsidy can be seen from the following table. It shows that

by availing both: the subsidy and accelerated depreciation, the simple payback period goes down to about 2 years from that of 4.23 years.

Sr. No.	Basis	Unit	Value
A	**BASIC DETAILS**		
	Capacity	LPD	1000
	SWH system cost	Rs.	2,48,000
	System output Temp.	deg.C.	60
	Average Ambient Temp	deg.C.	20
	Heat Gained by SWH	kcal/day	40,000
B	**LPG REQUIREMENT**		
1	Heat equivalent to 1 kg of LPG	Kcal	9,000
2	Conversion Efficiency	%	70
3	Actual Heat available	Kcal	6,300
4	LPG Required	kg/day	6.35
5	LPG Required	kg/month	190
C	**LPG COST**		
1	Rate of LPG Energy	Rs./kg	28
2	LPG required per day	Rs.	177.78
3	LPG required per month	Rs.	5333
4	LPG required per year (11 months)	Rs.	58,667
D1	**ECONOMICS - CASE-1: NO SUBSIDY**		
a	Return on Investment	%	24
b	Simple Payback periood	**Years**	**4.23**
D2	**ECONOMICS - CASE-2: WITH SUBSIDY**		
1	SWH collector are installed	sq.m.	16
2	MNRE subsidy per sq m of collector area	Rs.	3,300
3	Additional sibsidy from State Government	Rs.	-
4	Total Government subsidy	Rs.	52,800
	Cost of SWH System	Rs.	1,95,200
a	Return on Investment	%	30
b	Simple Payback periood	**Years**	**3.33**
D3	**CASE-2: WITH SUBSIDY & ACCELERATED DEPRECIATION**		
1	80% DEPRECIATION DURING FIRST YEAR	Rs.	74,400
2	Government subsidy	Rs.	52,800
	Total Government subsidy & Depreciation benefit	Rs.	1,27,200
	Cost of SWH System	Rs.	1,20,800

a	Return on Investment	%	49
b	Simple Payback periood	**Years**	**2.06**

ASSESSMENT OF OVERALL PROJECT EFFECTIVENESS:

The installed SWH system has been in use for day to day operations and HUL is satisfied with the consistant performance delivered by the ETC SWH system. However, they have a concern that during the monsoon the SWH system does not provide water hot enough for cleaning/washing applications. Also the space requirement of the SWH installtion is another matter of concern.

14.2.6 Punjab – Food Processing Industry

Location of Project	Channo, Patiala, Punjab
Year of Installation	2010
Name of Project Implementer	Pepsico
System Capacity	2000 LPD at 80 °C
Industrial Segment Targeted	Food Processing Industry
Project Objective	Reduce Diesel Consumption for boiler feed water
Project Target	Low Temperature (80 °C) hot water

PepsiCo entered India in 1989 and has grown to become the country's largest selling food and Beverage Company. One of the largest multinational investors in the country, PepsiCo has established a business which aims to serve the long term dynamic needs of consumers in India. PepsiCo nourishes consumers with a range of products from treats to healthy eats that deliver joy as well as nutrition and always, good taste. PepsiCo India's expansive portfolio includes iconic refreshment beverages Pepsi, 7 UP, Mirinda and Mountain Dew, in addition to low calorie options such as Diet Pepsi, hydrating and nutritional beverages such as Aquafina drinking water, isotonic sports drinks - Gatorade, Tropicana 100% fruit juices, and juice based drinks – Tropicana Nectars, Tropicana Twister and Slice, non-carbonated beverage and a new innovation Nimbooz by 7Up. Local brands – Lehar Evervess Soda, Dukes Lemonade and Mangola add to the diverse range of brands. PepsiCo has several plants in the country. One of the company's plant- Channo, Patiala in the State of Punjab was using diesel for boiler feed water heating. Hot water at around 80 °C is required for boiler feed water. The per day consumption of diesel is around 17 litres costing to Rs 1.96

lakhs in a year. The plant management decided to reduce diesel consumption for boiler feed water and installed Solar Water heating system of 2000 lpd.

Cost benefit analysis of SWHS Systems at Pepsico

ECONOMICS OF SWHS	
Amount of energy required in heating 2000 ltrs. of water upto 80 Deg. C assuming 22 Deg. C as avg. inlet water temp.	2000X1X(80-22)= 116000 kcals.
1 litre of Diesel at 70% efficiency gives Diesel saved per day	7000 kcals. 116000/7000 = 17 litres
Annual Diesel saving for 320 days taking effect of cloudy days into consideration	17 Ltrs.X320 days= 5303 litres
Amount saved per annum @ Rs. 37/ltr days of SWHS working per annum	5440X37 = Rs 196206/-
Cost of Solar Water Heating System	Rs. 7.86 Lakh
100% depreciation benefit in Ist. Year (33 % tax savings)	7.86X33% = Rs 2.59 Lakh
Investment recovery in Ist. Year	1.96+2.59 = Rs 4.55 Lakh
Payback period of System	7.86-4.55 Lakh = 3.31/1.96= 1.69 years
i.e Payback period of Solar Water Heating System **2.69 years**	

14.2.7 Pharmaceutical Industry

Year of Installation	2010
Name of Project Implementer	Ranbaxy Laboratories Ltd.
System Capacity	15000 LPD at 60 °C
Industrial Segment Targeted	Pharmaceutical Industry
Project Objective	Reduce Diesel Consumption for boiler feed water
Project Target	Low Temperature (60 °C) hot water

Ranbaxy Laboratories Limited (Ranbaxy), India's largest pharmaceutical company, is an integrated, research based, international pharmaceutical company, producing a wide range of quality, affordable generic medicines, trusted by healthcare professionals and patients across geographies. Ranbaxy today has a presence in 23 of

the top 25 pharmaceutical markets of the world. The Company has a global footprint in 46 countries, world-class manufacturing facilities in 7 countries and serves customers in over 125 countries. Ranbaxy's mission is 'Enriching lives globally, with quality and affordable pharmaceuticals. At one of its plant, diesel was used for boiler feed water heating to a temperature of around 60 °C. Per day consumption of diesel was about 82 litres, and costing to Rs 7.62 lakhs in a year. Plant management has decided to reduce diesel consumption and installed solar water heating system of 15000 lpd.

Cost benefit analysis of SWHS Systems at Ranbaxy

ECONOMICS OF SWHS	
Amount of energy required in heating 15000 ltrs. of water upto 60 Deg. C assuming 21.50 Deg. C as avg. inlet water temp.	15000X1X(60-21.50)= 577500 kcals.
1 litre of Diesel at 70% efficiency gives Diesel saved per day	7000 kcals. 577500/7000= 82.50 litre
Annual diesel saving taking effect of cloudy days into consideration for 330 days	=82.5X330= 27225 litre
Amount saved per annum @ Rs. 28/ltr days of SWHS working per annum	27225X28 = Rs 762300/-
Cost of Solar Water Heating System	Rs. 21.38 Lakh
Capital Subsidy	Rs. 08.58 Lakh
100% depreciation benefit in (80% in 1st year & 20% in 2nd) (33 % tax savings)	21.38X33%=Rs 7.05 Lakh
Investment recovery in Ist. Year	08.58+7.05+7.62=Rs 23.25 Lakh
Payback period of System	Less than 1 year

14.2.8 Gurgaon – Textile Industry

Location of Project	IMT Manesar, Gurgaon
Year of Installation	2007
Name of Project Implementer	Chelsea Jeans
System Capacity	50000 LPD at 60 °C
Industrial Segment Targeted	Textile Industry

Technology	Hybrid SWH
Project Objective	Reduce Diesel Consumption for boiler feed water
Project Target	Low Temperature (60 °C) hot water

Project Description

The washing of the denim clothes, requires hot water at 55-90°C, for half of the cycle and most of the energy is required for heating the water. Conventionally the water heating requirement is met through a steam boiler running on Furnace oil or Diesel. In order to save energy and reduce operating cost as well as to protect the environment from harmful emissions, Chelsea Textile mills decided to use a hybrid solar water heating system coupled with waste heat recovery to generate hot water for their process application. A 10,000 liters insulated tank with a plate heat exchanger is used to transfer heat from the primary circuit. This solar tank is connected to the main tank of 50,000lts where water heated from solar energy is mixed with water heated by waste recovery system. This main tank is well insulated and behaves as a consumption tank.

Cost benefit analysis of SWHS Systems at Chelsia

ECONOMICS OF SWHS	
Amount of energy required in heating 50000 ltrs. of water upto 60 Deg. C assuming 22 Deg. C as avg. inlet water temp.	50000X1X(60-22)= 1900000 kcals.
1 litre of Diesel at 70% efficiency gives Diesel saved per day	7000 kcals. 1900000/7000= 271 litres
Annual diesel saving taking effect of cloudy days into consideration for 320 days	271X320= 86857 litres
Amount saved per annum @ Rs. 31/ltr days of SWHS working per annum	86857X31= Rs 2692571/-
Cost of Solar Water Heating System	Rs. 79.28 Lakh
80% depreciation benefit in Ist. Year (30 % tax savings)	79.28X80%X30%= Rs 19.02 Lakh
Investment recovery in Ist. Year	19.02+26.92=Rs 45.95 Lakh
Payback period of System	79.28 – 45.95 Lakh= 33.33/26.92= 1.24

	years
i.e Payback period of Solar Water Heating System **2.24 years**	

14.3 – Annexure-III- Primary Data Collection Format

Part I: Industry Overview & General Information				
Name of Industry				
Address				
Contact Details	Name			
	Designation			
	Email			
	Tele			
	Fax			
Sector/Industrial Segment	☐Auto Components Including Electroplating		☐Food Processing (Seafood)	☐Fertilizer
	☐Pharmaceuticals and Drugs		☐ Paint Chemicals	☐Textile
	☐Rural Industries – Rice Mills		☐ Dyes &Chemicals	☐Sugar
	☐Rural Industries – Silk Reeling		☐Pulp & Paper	☐Chemical
	☐Food Processing (Dairy)		☐Industrial Canteen	
14.3.1.1 Cluster	**Location:**		**State:**	
Products & Production Details	**Name of Product**		**Annual Production Details,** *please specify units*	

Form of Energy Utilized & Sources	**Form ofEnergy**	**Source**	**Rate** *please specify unit*	**Annual Consumption,** *please specify unit*
	☐Electricity			
	☐Coal			
	☐Coke			
	☐ FO			
	☐ LDO			
	☐ HSD			
	☐ LPG			

	☐ NG			
	☐ Naptha			
	☐Biomass/Agro waste			
	☐Others *please specify……*			
Process Type	☐ Batch type	☐ Continuous	☐ Seasonal	
	☐ Engineering	☐ Others *please specify……*		
Process Flow Diagram	*Please collect or draw in separate sheet and attach*			
Part II: Areas of Hot Water / Steam Application *(To be filled based on process requirement/understanding)*				
Potential Areas / Equipments for Hot Water / Hot Air Application	1. 2. 3. 4.			
Hot Water Parameters for Area - 1 (Please specify the name of area and its application)	Quantity of Hot Water Required, Please specify units			
	Temperature, deg C			
	Present Source of Hot Water Generation			
	Type of Fuel Used			
	Quantity of Fuel required for the Hot Water Generation, Please specify the unit			
	Present Electrical Energy Consumption with associated auxiliary consumption, Please specify units			
	Usage Timing	☐ 0-6 hours	☐ 6 - 12 hours	
		☐ 12-18 hours	☐ 18 - 24 hours	
Hot Water Parameters for Area - 2 (Please specify the name of area and its application)	Quantity of Hot Water Required, Please specify units			
	Temperature, deg C			
	Present Source of Hot Water Generation			
	Type of Fuel Used			
	Quantity of Fuel required for the Hot Water Generation, Please specify the unit			

	Present Electrical Energy Consumption with associated auxiliary consumption, Please specify units	
	Usage Timing	☐ 0-6 hours ☐ 6 - 12 hours ☐ 12-18 hours ☐ 18 - 24 hours
Hot Water Parameters for Area -3 (Please specify the name of area and its application)	Quantity of Hot Water Required, Please specify units	
	Temperature, deg C	
	Present Source of Hot Water Generation	
	Type of Fuel Used	
	Quantity of Fuel required for the Hot Water Generation, Please specify the unit	
	Present Electrical Energy Consumption with associated auxiliary consumption, Please specify units	
	Usage Timing	☐ 0-6 hours ☐ 6 - 12 hours ☐ 12-18 hours ☐ 18 - 24 hours
Part III: Technical Specifications / Design Parameters of installed Hot Water Generation Systems		
Hot Water Generation Sources (in case of dedicated Hot Water Generator System installed)	Type of generator	
	Capacity, TPH	
	Operating Temperature Range, oC	
	Fuel used	
	Fuel firing rate, *please specify unit*	
	Whether SWHs explored	Yes/NO
	Whether SWHsinstalled	Yes/NO If NO Specify the Reasons :
	Mode	Stand alone / Hybrid
If SWHs System Installed as Standalone	Earlier hot water source	
	Capacity, LPD	
	Make	
	Type	FPC/ETC
	Water inlet temperature, deg C	
	Water outlet temperature, deg C	

	Total Usage hours	
	Usage Timing	☐ 0-6 hours ☐ 6 - 12 hours ☐ 12-18 hours ☐ 18 - 24 hours
	Fuel consumption with earlier source (Before Implementation of SWH System)	
	Electricity consumption with earlier source (Before Implementation of SWH System)	
	Present electricity consumption (With SWH System)	
	Monitory savings achieved, Rs/annum	
	Total Cost of Implementation of SWH Systems	
	Operating Cost as percentage of Initial Investment in SWH	
	Source of finance	
	Subsidy/rebate under any government promotional scheme	
	Any issues/barriers	
	Other (specify)	
If SWHs System Installed as Hybrid	Conventional hot water source	Water heater/ Boiler
	Capacity, LPD	
	SWH capacity, LPD	
	SWH Make	
	Type	FPC/ETC
	Water inlet temperature to SWH , deg C	
	Water outlet temperature of SWH, deg C	
	Water outlet temperature of hot water generator, deg C	
	Steam Pressure, kg/cm^2	
	Use timings	

	Fuel consumption with earlier source (Before Implementation of SWH System)	
	Electricity consumption with earlier source (Before Implementation of SWH System)	
	Present electricity consumption (With SWH System)	
	Monitory savings achieved, Rs/annum	
	Source of finance	
	Subsidy/rebate under any government promotional scheme	
	Any issues/barriers	
	Other (specify)	
Part IV: Boiler House Application		
Industrial Boiler	Capacity, TPH	
	Make	
	Steam requirement, TPH	
	Hours of operation	
	Steam Pressure, Kg/cm^2	
	Average Feed water temperature, deg C	
	Fuel type	
	Fuel Consumption, *please specify unit*	
	Status of condensate recovery	
	Percentage of condensate recover	
	Economizer/Air pre heater	
	Make water requirement, kg/hr	
	Combustion Air Temperature, deg C	
Auxiliary Heating in Oil fired Boilers to control the Oil	Type of Oil Fired	LSHS/ FO etc.
	Temperature to be maintained for Required Viscosity	

Viscosity	Present Energy Source of Auxiliary Heating	Electricity / Steam / Process Waste heat
	Total Fuel Consumption/ Steam Consumption, *please specify unit*	
	Utilization Temperature *(for sources other than electricity)*	
	Number of Oil Storage Tanks and storage capacity in Tank Yards	
	Number of Oil Storage Tanks and storage capacity in Boiler House	
	Length of Fuel Pipe with Auxiliary heating	
Part V: Process – Chilling / Cooling Requirement		
Process Application - Low temperature requirement, cooling/ Chilling	Chilled Water Requirement in Process	☐Yes ☐No
	Capacity, TR	
	Type – VCS/VAM	
	Make	
	SEC, kW/TR	
	Temperature requirement, deg C	
	IF VAM, source of fuel	
	Steam / Hot water requirement, kg/hr	
	Steam Pressure / Hot water temperature, deg C	
	Others, *please specify*	
Part VI: Administration Office – Chilling / Air Conditioning Requirement		
Administration Office - Low temperature requirement, cooling/ Chilling for Comfort Cooling	Administration Office	☐Air Conditioning ☐Non – A.C.
	Type of AC System	☐Centralized AC ☐Package AC.
	Capacity, TR	
	Type – VCS/VAM	
	Make	
	SEC, kW/TR	

	Temperature requirement, deg C	
	IF VAM, source of fuel	
	Steam / Hot water requirement, kg/hr	
	Steam Pressure / Hot water temperature, deg C	
	Others, *please specify*	

Part VII: Industrial Canteen – Chilling / AC Requirement		
Industrial Canteen - Low temperature requirement, cooling/ Chilling for Comfort Cooling	Industrial Canteen	☐Air Conditioning ☐Non – A.C.
	Type of AC System	☐Centralized AC ☐Package AC.
	Capacity, TR	
	Type – VCS/VAM	
	Make	
	SEC, kW/TR	
	Temperature requirement, deg C	
	IF VAM, source of fuel	
	Steam / Hot water requirement in VAM, kg/hr	
	Steam Pressure / Hot water temperature required in VAM, deg C	
	Additional Quantity and temperature of Hot Water Required for washing/heating purpose in Canteen, Please specify units	
	Present Mode of Cooking	
	Fuel Used for Cooking	
	Fuel Requirement for cooking, Please specify the unit	
	Others, *please specify*	

Part VIII: Process – Hot Air Requirement		
Process Application - Hot Air Requirement	Name of Process Area where Hot Air is required	
	Quantity of Hot Air required, Please specify units	
	Temperature requirement, deg C	
	Present Source of Hot Air Generation	
	Type of Fuel Used;	
	Quantity of Fuel required for Hot Air generation, Please specify unit	
	Present Electrical Energy Consumption with associated auxiliaries, kWh/annum	
	Others, *please specify*	

14.4 Annexure – IV – Stakeholder Consultation Format

Stakeholder Details			
Type of Stakeholder Consulted*(Please Tick)*	☐ Energy Audit Consulting Firm ☐ Equipment Manufacturers With Hot Water as Input	☐ ESCO ☐SWH Manufacturers	
Name of Organisation			
Address			
Contact Person Details	Name :	Cell :	
	Designation:	Tele :	
	Email:	Fax :	
Years of Experience In this Business			
Industrial Segments For Which Services Are Provided *(Please Tick)*	☐Auto Components Including Electroplating	☐Food Processing (Seafood)	☐Fertilizer
	☐Pharmaceuticals and Drugs	☐ Paint Chemicals	☐Textile
	☐Rural Industries – Rice Mills	☐ Dyes &Chemicals	☐Sugar
	☐Rural Industries – Silk Reeling	☐Pulp & Paper	☐Chemical
	☐Food Processing (Dairy)	☐Industrial Canteen	
SWH Recommendations / Services			
Hot water, steam, other low-temperature heating as well as process cooling & comfort cooling requirements	*(Brief description ofhot water, steam, other low-temperature heating as well as process cooling and comfort cooling requirements for various processes for each industry segment above.)*		

Briefly Describe the Services/Recommendations Provide which involves SWH applications for Above Industry Segments	1. 2. *(Brief description about the recommendation/service provide involving SWH application, description about the specific technology used, year of implementation, industry segment etc.)* ***(For all above listed Projects Please Fill up Annexure- 1)***	
Barriers for Implementation of SWH applications in Above Industry Segments *(Please Tick all applicable, add more if required))*	☐Space Constraint ☐Lack Of Knowledge ☐Technology Not Matured ☐Abundant Low Price Fuel Availability ☐Others (Please Specify) 1. 2.	☐Capital Intensive ☐Long Pay-back Period ☐Any Industry Segment Specific Barrier (Industry Segment: ……....) 1. 2.
Most Preferred Mode of Finance for Implementation SWH based projects *(Please Tick all applicable, add more if required))*	☐100% Self Investment ☐Partially Through Loan ☐Subsidy / Incentives ☐Others (please specify).	☐Third Party Investment (like ESCO) ☐CDM / Carbon Finance ☐Others (please specify).

Stakeholders Views

(Please provide your views and comments on the following Issues)

1. **Domestic Demand for SWH systems and Exports**
   -
   -
   -
2. **Technology Developments &Preferred Technology by Industries**
   -
   -
   -
3. **Cost of SWH production and Future Cost Trends**
   -
   -
   -
4. **SWH Manufacturing Capacity targets (Individual Stakeholders as well as Industry as whole, please mention target year)**
   -
   -
   -

5. Major SWH industry drivers • • •
6. Future growth prospects for the Penetration of SWHs in identified industry segments. • • •
7. SWH Product Information (supported by technical leaf lets, cost etc. From SWH manufacturers) • • •

14.5 Annexure – V –Format for the Preparation of Case Studies

PROJECT TITLE :	
Industry Segment For Which SWH Project is Implemented :	
Location / Area where Project Implemented/Suggested :	
Year of Project Implementation/Completion :	
Name of Project Implementer :	
Type of Project Implementer	☐ Industry Owner ☐ ESCO ☐ Distribution Utility ☐ Others (Specify)…… ☐ SWH Manufacturer
Purpose / Objective for Implementation of SWH Project	☐ Demonstration project / Pilot Project ☐To Reduce Fossil Fuel Consumption for Hot Water Generation ☐To Reduce Electricity Consumption for Hot Water Generation ☐ To Reduce Electricity Consumption for Chilled Water Generation ☐ To Explore Renewable Energy sources for heating/cooling ☐To Reduce Carbon Emissions ☐ Other (specify)…….
Project Target	☐ Low Temperature Preheating Application (e.g. Boiler Feed Water Preheating, Furnace Oil Preheating etc.) ☐ Process Heating (Hot Water, Hot Air etc.) ☐ Process Cooling (Chilled Water Generation through VAM) ☐ Comfort Cooling (Chilled Water Generation through VAM) ☐ Hot Air Generation / Drying Application ☐ Other (specify)……..
Technology Used	(Specify the technologies associated with SWH application in the project like FPC/ETC or concentrated collectors etc.)
Drivers for Project Implementation	☐ Accelerated Depreciation Benefit for SWH Projects ☐Cost Benefit Analysis ☐ Regulatory Directives ☐Innovative Financing Mechanism for SWH Projects

	☐ To Improve the Product Quality ☐ Others (Specify) …….

Detailed Description of Project:

(Please provide detailed description of previously installed system, its operation, type of fuel used, schematic diagram, description of proposed/modified system, technology used, implementation challenges etc.)

Details of Any Specific Financial Assistance Received from the Government:*(e.g: Rebate /Subsidy / Accelerated Depreciation / Loan etc.)*

Cost Benefit Analysis:

(Please provide detailed information related to the technical parameters (temperature requirement, quantity of fuel/electricity used, power consumption in auxiliaries), operating and maintenance cost and investment made for the proposed SWH project)

ECONOMICS OF SWHS	
Amount of Heat required to heat (M)……ltrs of water per day upto(T_1)……. °C with (T_2)…… °C average inlet Water Temp.	M X (T_1-T_2) = …… K Cals
Existing Fuel Consumption Rate Per Day (FC) *(Specify unit & Fuel type)*Fuel Type ……..	……. Unit of Fuel / Day
FuelCostSaved Per Annum for (D)……..days of SWHS working per annum @ (C) Rs. …… / Unit of Fuel *(Unit of Fuel could be kWh, kg, liter etc.)*	A = FC X D X C =Rs. …….lacs
Cost of Solar Water Heating System & Other Associated Costs (C_{swh})	Rs. ……...lacs
Amount saved in 1st Year In terms of energy Saving	A = Rs. ……lacs
In terms of 80% depreciation benefit in 1st Year under Income Tax Act (30% tax saving)	B = A X 30% X 0.8 = Rs…...lacs
Investment Recovery in 1st Year (A+B)	Rs. ……lacs

Net Investment = Total Cost – Saving in 1st Year (C_{swh} – (A+B))	Rs. ……lacs
Pay Back Period of System	…….. Years

Barriers Addressed / Implementation Challenges:

Assessment of Overall Project Effectiveness:

What are the Perceived Advantages/ Disadvantages After Implementation of SWH System: *(For ex in terms of cost, not enough sunny days, longer time to heat water, maintenance etc.)*

Repeatability of the Implemented Measures in the same/other Industrial Segment:

Contact Details	Organisation: Name: Cell No: Mail ID:
Sources	(e.g. reports on project)