Executive Summary

• Water is a scarce commodity in India and will only become more scarce in the future

• SPX Cooling Technologies has the solutions for water related issues with Dry Cooling Technologies

• The latest technologies in Dry Cooling are available including flat single row and multi row tubes

• Dry cooling in many Indian provinces is an economically attractive alternative to other cooling methods

Dry Cooling can help India produce power economically while saving water
Population growth means increased direct use of water as well as indirect use through increased need for agriculture and power.

Most of the population growth will be in urban areas which will intensify water needs in those areas.

Industrialization will continue in India. Industrial companies use water for multiple processes.


Concentrated Population and Industrialization growth will require more water.
Water Availability: Increasing Water Stress

Water availability is localized

- Semi-arid and arid zones have clear lack of water availability
- Tropical Wet & Dry areas rely on Monsoons which vary annually
- Humid / Subtropical areas also have greatest demand with priority on public consumption
- World Business Council added India and South Africa to areas of high water stress for 2025 (water withdrawn exceeds water available)

Large areas of India may not have a sustainable source of water for power

SPX Overview

SPX Facts

Headquarter: Charlotte, US
SPX Revenue: $6Bn (INR 33000 Cr)

- Employees: 17000+ globally

- Thermal Equipment and Services Centers of Excellence:
  - Ratingen, Germany
  - Brussels, Belgium
  - Bridgewater, NJ USA
  - Overland Park, KS USA

SPX is a diverse global company focused on Power Generation
SPX is a diverse global company with a broad product portfolio focused on Power & Energy.
Principle Concepts for Cooling

Evaporative Cooling
- Once Through Cooling
- Evaporative / Hybrid Cooling Tower

Parallel Systems
- Parallel Condensing System
- Parallel Cooling System

Dry Cooling
- Air Cooled Condenser (ACC)
- Indirect Cooling

Dry Cooling can help produce power economically while saving water
## Cooling Concept Comparisons

<table>
<thead>
<tr>
<th></th>
<th>Once Through</th>
<th>Evaporative Cooling Tower</th>
<th>Parallel Systems</th>
<th>Indirect Dry Cooling Tower</th>
<th>Air Cooled Condenser</th>
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<tbody>
<tr>
<td><strong>Water Use</strong>*</td>
<td>750 GPM</td>
<td>750 GPM</td>
<td>Varies</td>
<td>0 GPM</td>
<td>0 GPM</td>
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<td><strong>Power Use</strong>*</td>
<td>13.5 kW/MW</td>
<td>19 kW/MW</td>
<td>19 kW/MW</td>
<td>10 kW/MW</td>
<td>19 kW/MW</td>
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<tr>
<td><strong>Advantages</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cost Effective with small footprint</td>
<td>Low continuous use of water</td>
<td>Equipment sized for water availability</td>
<td>Can be located at fuel source</td>
<td>Can be located at fuel source</td>
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<tr>
<td></td>
<td>Low back pressure operation</td>
<td>Low back pressure operation</td>
<td>Smaller footprint than full dry</td>
<td>Low auxiliary power usage</td>
<td>No Water Usage</td>
</tr>
<tr>
<td></td>
<td>No noise pollution</td>
<td></td>
<td></td>
<td>Less time for permits</td>
<td>Less time for permits</td>
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<tr>
<td><strong>Disadvantages</strong></td>
<td>Plant site to be near water</td>
<td>Reliable water source required</td>
<td>More complicated operation</td>
<td>Largest footprint</td>
<td>Highest installed cost</td>
</tr>
<tr>
<td></td>
<td>Conflicts for water availability</td>
<td>Water treatment required</td>
<td>Highest upfront cost and footprint than full wet</td>
<td>Lowest cycle efficiency</td>
<td>Lowest cycle efficiency</td>
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<tr>
<td></td>
<td>Environmental concerns</td>
<td>Plume formation</td>
<td>Maintenance costs</td>
<td>Cooling driven by dry-bulb temperature</td>
<td>Cooling driven by dry-bulb temperature</td>
</tr>
</tbody>
</table>

* Note: values are estimates of the entire system and may change with system design and conditions

**Dry Cooling is the best option when water is not a long term option**
Dry Cooling: Air Cooled Condenser

Background

- Air passes through fan and over coils to both reject heat and condense steam
- Over 90% of Dry Systems are ACC’s

Advantages

- Can be located at fuel source
- No water required
- No plume formation
- No impact on environment
- Less permits & time for permitting required

Disadvantages

- Higher installed cost
- Larger footprint
- High parasitic power usage
- Lower cycle efficiency
  - Cooling driven by dry-bulb temperature

Common as water scarcity, cost, and risk increase
SPX is a Leading Global Supplier of Engineered Products and Solutions that are Critical to the Thermal Performance and Safety of Many Types of Power Plants.
Product Description

Directly condense the turbine exhaust steam from the steam turbine and return condensate to the boiler without water loss.

They are frequently used in electrical power plants of all sizes

Features

Air Cooled Condenser is a direct dry cooling system where the steam is condensed inside air-cooled finned tubes. Since there is no intermediate surface condenser like Indirect dry cooling, the overall performances is better.
## Challenges
- High operating flexibility
- Operating cost
- Diverse and challenging climates, from hot to freezing conditions
- Strict environmental imposition including low noise

## Existing SPX Solutions
**Dry Cooling Systems with SPX SRC™ finned tube technology:**
- Forced Draft
- Induced Draft (Hexacool®)

## What makes the product special
- Elimination of additional water usage from the condensing power cycle
- Excellent corrosion and freeze resistance
- Long-term mechanical and thermal integrity
- Low fan power consumption
- Flexibility in power plant site selection
- Decreased time required for plant permitting

## Current Activities
- More than 100 units in commercial operations
- More under design, construction and commissioning
Direct Dry Cooling Technology
A-Frame: Operational Detail

Heat transfer tubes are critical to ACC performance

Basics of Operation

- Air travels up through fan and passes over tubes
- Steam arrives through ducting and condenses in tubes as heat is transferred to air
- Condensate at bottom of tubes returns to system
**Direct Dry Cooling Technology (ACC)**

**Flat Shape Tube**

**Carbon steel / Aluminium**

**General Design Features**

**Core Tube**
- flat shape
- steel tube
- Aluminium coated

High steam side flow area
- brazed fins
- aluminium fin

**Single Row System**
- suppression of steam side maldistribution
- flexibility to operation requirements (flow area; pressure drop)

Proven Technology

June 2013
Gas application - Combined Cycle Power Plants

<table>
<thead>
<tr>
<th>Combined Cycle projects</th>
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</thead>
<tbody>
<tr>
<td>Turano - 800 MW</td>
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<tr>
<td>Italy</td>
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<tr>
<td>Langage – 850 MW</td>
</tr>
<tr>
<td>United Kingdom</td>
</tr>
<tr>
<td>Alba – 2x800 MW</td>
</tr>
<tr>
<td>Bahrein</td>
</tr>
<tr>
<td>Riyadh PP11 – 2x850 MW</td>
</tr>
<tr>
<td>Saudi Arabia</td>
</tr>
<tr>
<td>Goreway – 800 MW</td>
</tr>
<tr>
<td>Canada</td>
</tr>
<tr>
<td>Rio Bravo – 3X515 MW</td>
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<tr>
<td>Mexico</td>
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</tbody>
</table>

SPX is a full-line, multi-service manufacturer of

- Air-cooled condensers

Products and solutions are marketed to

- Gas
- Solar
- Coal
- Renewables - Biomass
<table>
<thead>
<tr>
<th>Project Name</th>
<th>Type of plant</th>
<th>Country</th>
<th>Plant MW</th>
<th>Year</th>
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<tr>
<td>Samra III</td>
<td>Combined Cycle Power Plant</td>
<td>Jordan</td>
<td>140</td>
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<td>San Luis de la Paz</td>
<td>Combined Cycle Power Plant</td>
<td>Mexico</td>
<td>205</td>
<td>2014</td>
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<td>Dominion - Front Royal - Warren County</td>
<td>Combined Cycle Power Plant</td>
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<td>Denizli</td>
<td>Combined Cycle Power Plant</td>
<td>Turkey</td>
<td>200</td>
<td>2012</td>
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<td>Chilca Uno</td>
<td>Combined Cycle Power Plant</td>
<td>Peru</td>
<td>810</td>
<td>2011</td>
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<td>Deer Creek</td>
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<td>Kallpa</td>
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<td>Tracy GWF</td>
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<td>Al Qatrana</td>
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<td>Colusa (CA)</td>
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<td>Halton Hills (Ontario)</td>
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<td>Amman East Power</td>
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<td>400</td>
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</tr>
</tbody>
</table>

* Selected projects amongst hundreds of references
Case Study - Gas - Combined Cycle Turano Lodigiano (ACC) Italy

Location – Bertonico-Turano Lodigiano in Northern Italy, a 800 MW Combined Cycle Power Plant

Challenge - Allow maximum operating flexibility in accordance with legal atmospheric pollutant emission criteria. Focus on the real needs, proactive collaboration, technical expertise and careful planning and monitoring of work

SPX Solution – Focus on environmental and architectural issues and an excellent operating flexibility

Customer Benefit – High performance, low back pressure even during Winter conditions. Overall net efficiency of the plant > 57% - Customer’s official satisfaction letter
Case Study – Gas - Combined Cycle Langage (ACC), United Kingdom

Location – Langage, Plymouth, United Kingdom. A 850 MW Combined Cycle Power Plant.

Challenge – Ability to provide grid stabilization and spinning reserve services when integrated on the grid with wind energy.

SPX Solution – quick response and low load “parking” at night while remaining below air emissions limits.

Customer Benefit – With an extraordinary architectural design that blends into the natural surroundings, Langage is now a local landmark.
### Dry Cooling Solutions in Solar Air Cooled Condenser

**Challenges**
- High operating flexibility
- Minimize operating and maintenance cost
- Hot, arid and dusty environment with large solar irradiation

**Existing SPX Solutions**
- Dry Cooling Systems with SPX SRC™ finned tube technology:
  - Forced Draft
  - Induced Draft (Hexacool®)

**What makes the product special**
- Elimination of additional water usage from the condensing power cycle
- Long-term mechanical and thermal integrity
- Low fan power consumption
- Special solution dedicated to solar tower systems

**Current Activities**
- 5 units in commercial operations
- More under design, construction and commissioning

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*June 2013*
Example of Solar Projects

- Hassi R’Mell – 150 MW
  Algeria
- Ain Beni Mathar – 470 MW
  Moroco

Reason for using Dry Cooling

- No water available at site
- Environmental regulations for water saving
- Environmental regulations, limiting the temperature increase in rivers and seaside
- Renewable sources
## Solar Power Plants Reference List

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Type of plant</th>
<th>Country</th>
<th>Plant MW</th>
<th>Year</th>
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</thead>
<tbody>
<tr>
<td>Ain Beni Mathar</td>
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<td>Hassi R’Mell</td>
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<td>Genesis</td>
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<td>South Africa</td>
<td>100 MW</td>
<td>2012</td>
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</tbody>
</table>
Case Study – Solar Hassi R’Mell (ACC), Algeria

- **Location** – Region of Hassi R’Mel in the province of Laghouat, Algeria, a 150 MW integrated solar Combined Cycle Power Station

- **Challenge** – Allow optimized power plant output in a high ambient temperature arid environment by optimizing the condensing capacity

- **SPX Solution** – Focus on an optimized solution with maximum flexibility for best turbine back pressure control in winter and summer conditions

- **Customer Benefits** – High performance dry cooling condenser without need of water in an arid area and integrated in an environment-friendly power plant with low carbon emissions

»Dry Cooling

June 2013
Product Description:
Air cooled condenser for coal fired power plants, behind steam turbine building with typical arrangement of 2x150 MW up to 2x1000 MW

Features:
• High efficiency SRC™ finned tubes
• Free-expansion tube bundles
• A-framed supported tube bundles
• Steel structure or round concrete columns support
• Low noise design for near & far field
• Low hot air recirculation design
• High wind design
### Challenges
- Large capacity steam condensing for maximum electrical output
- Coal mine areas with dusty and corrosive environment
- Diverse and challenging climates, from hot to freezing conditions with risks of mechanical wear
- Base load operation requiring high availability

### Existing SPX Solutions
- **SPX SRC™ Air Cooled Condenser – Direct Condensing**

### What makes the product special
- High efficiency thermal cycle with low back pressure and low power consumption for maximum heat rate
- High performance finned tubes with excellent cleaning ability for long term availability
- A-Frame supported tube bundles, allowing heat exchanger free thermal expansion for maximum reliability

### Current Activities
- More than 150 units in commercial operations
- Many more under design, construction and commissioning
Example of Projects

Zhenglan – 2x600 MW
China

Wuxiang – 2x600 MW
China

Longshan – 2x600 MW
China

Wygen – 100 MW
USA

Kusile – 6x800 MW
South Africa

Product Description:
Air cooled condenser for coal fired power plants, behind steam turbine building with typical arrangement of 2x120 MW up to 2x1.000 MW

Features:
- High efficiency SRC™ finned tubes
- Free-expansion tube bundles
- A-framed supported tube bundles
- Steel structure or round concrete columns support
- Low noise design for near & far field
- Low hot air recirculation design
- High wind design
Performance Curve for ACC

**Design Conditions**
- Steam Flow: DG 297.417 kg/s
- Back Pressure: PG 180 mbar
- Air Temperature: LG 38°C

Steam Dryness: xG 0.982 kg/kg
Barom. Pressure: bG 982.4 mbar
Wind Speed (m/s) (max.): 3.

All Fans at Full Speed

To read performance at actual load:
- use steam flow D (%) on horizontal axis, where:
  \[ D = 100 \times \left( \frac{D_{actual}}{DG} \right) \times \left( \frac{xG}{xG_{actual}} \right) \]
- use actual air temperature curve
- read actual turbine backpressure on vertical axis
## Coal Fired Power Plant - ACC Reference List

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Type of plant</th>
<th>Country</th>
<th>Plant MW</th>
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<td>Coal Fired Plant</td>
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<td>Kusile - Bravo</td>
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<td>Taiyuan 2</td>
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<td>China</td>
<td>2X330</td>
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</tr>
</tbody>
</table>

* Selected projects amongst dozens of references
Case Study - Coal
Yuanyanghu (ACC), China

Location – Yuanyanghu Coal Fired Power Plant 2x600 MW - NingXia province, China

Challenge - Fast track delivery and assembly of two units full scope ACC for a 1.320 MW coal fired plant.

SPX Solution – Extended experience in 2x600 MWW units, with more than 20 references in commercial operation; high efficiency SRC ™ finned tubes, A-Frame supported.

Customer Benefit – Commercial operation of Unit 1 in 21 months, from start of design, with successful performance test.
Case Study - Coal Kusile (ACC), South Africa

Location – Kusile, Coal Fired Power Plant in Mpumalanga province, South Africa. 6X800 MW units for a total capacity of 4.800 MW operated by Eskom

Challenge – Turnkey Project with fan deck at 70 m elevation. Construction activities at height and usage of large cranes are first safety concerns

SPX Solution – “Safety first” has imposed a construction strategy of assembly of large modules on ground floor (up to 135T) and lift with huge crane capacity (850 Ton)

Customer Benefit – Safe site activities, ease of quality inspection, secured construction schedule

Dry Cooling
Thanks for your kind attention

For queries contact us: Thermax SPX Energy Technologies Ltd, Pune India
+91-20-6730 8896 or info@thermaxspx.com