Eliminating Energy Waste in Hospitals

Arjun P. Gupta

This presentation has been prepared by Smart Joules for “Taller Técnico sobre Eficiencia Energética en Hospitales y Escuelas: "Múltiples Beneficios y Oportunidades"” held on September 25, 2018 in Mexico City and organized by the IEA. The materials contained herein have been prepared for discussion purposes, are strictly confidential, and not to be shared, used, reused or reproduced in any way without our prior approval.

September 25, 2018
Proprietary & Confidential
Introduction
Mission: To Eliminate Energy Waste Through Innovations in Continuous Energy Optimization

Arjun P. Gupta, CEO
Ujjal Majumdar, COO
Sidhartha Gupta, CFO

Champions of Change

Empower Each Team Member with a Sense of Ownership
Pursue Growth and Learning
Get Shit Done
Build a Positive Team and Family Spirit
Be Passionate, Determined and Bold
Maintain a High Level of Transparency and Honesty

Core Values

Team
50
100% YoY Growth

Product Development
17
Central Resources
7
Project Design & Execution
8
Maintenance
7

Product Deployment
6
Product Testing and Utilization
5

Government of India
Confederation of Indian Industry
Hello Tomorrow
The Economic Times
Huffington Post
BW Business World
IEA
UNYCC
ADB

National Energy Conservation Award
National Award for Excellence in Energy
Top 100 Technology Startups in the World
International Energy Efficiency Expert
Young Changemaker
Top 20 Asian Clean Energy Entrepreneurs
How Important is Eliminating Energy Waste?

92%

300 Million

700 Million till 2011
How Important is Eliminating Energy Waste?

Indian GHG Scenario

Share of cumulative abatement between 2010-2035
- Efficiency: 51%
- Renewables: 32%
- Biofuels: 1%
- Nuclear: 8%
- CCS: 8%

Bureau of Energy Efficiency Website:
https://www.beeindia.gov.in/sites/default/files/PAT%20PPT%20%28Overview%29%20Regional%20Workshops.pdf
What Is the Indian Government Doing?

Indian government looks to save Rs 35,000 crore by making buildings energy efficient

According to Government estimates, retrofitting existing buildings with energy efficient lights and appliances will help save approximately 30-40 billion units per year.

International Business Times, June 2017
http://www.ibtimes.co.in/indian-government-looks-save-rs-35000-crore-by-making-buildings-energy-efficient-731884
What Is the Indian Government Doing?


What Is the Indian Government Doing?

Outcome – PAT 1

- **Energy Saving**: 5635 MW, 8.67 mtoe, 1.25% of India’s total primary energy supply
- **Emission Reduction**: 31 Million tonnes of CO2, 1.93% of India’s total emissions
- **Capacity Building**: 6000+ Engineers and operators, 18718 Energy Auditors & Managers, 219 Accreditation
- **Savings**: Saved due to energy consumption, Rs. 9,500 Crores
- **Investment**: Encouraged investments for energy efficient technologies, Rs. 24,517 Crore invested

Bureau of Energy Efficiency Website:
https://www.beeindia.gov.in/content/pat-3
Eliminating Electricity Deficit through Energy Efficiency in India: An Evaluation of Aggregate Economic and Carbon Benefits

Jayant Sathaye and Arjun P. Gupta
International Energy Studies Group
Environmental Energy Technologies Division

April 2010
## List of 94 Energy Service Companies (ESCOs) empanelled with BEE with validity till 30th March, 2017

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of Organization</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ingersoll Rand Climate Solutions Private Limited&lt;br&gt;Plot No.35, KIADE Industrial Area, Bidadi, Sengaluru – 562 109, Karnataka&lt;br&gt;Mr Gopi Krishna&lt;br&gt;Ph: 09035611888&lt;br&gt;<a href="mailto:Gopi.Jayan@irco.com">Gopi.Jayan@irco.com</a></td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Schneider Electric India Private Limited&lt;br&gt;4th Floor, Electro wing A, Eros Business Park, Marathahalli, Sarajpur Outer Ring Road, Bangalore – 560103, Karnataka&lt;br&gt;Ms Bindu Thomas&lt;br&gt;Ph: 08080549082&lt;br&gt;<a href="mailto:bindu.thomas@schneider-electric.com">bindu.thomas@schneider-electric.com</a></td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Salzer Electronics Limited&lt;br&gt;Samidhettipalayam (PO), Jothipuraam (Via), Coimbatore – 641 047, Tamil Nadu&lt;br&gt;Mr Sathish Kumar&lt;br&gt;Ph: 09445522351&lt;br&gt;<a href="mailto:sathish.kumar@sallerneenergy.com">sathish.kumar@sallerneenergy.com</a></td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Swelect Energy Systems Limited&lt;br&gt;Numeric House, 3rd Floor, Number 5, Sir P. S. Swasamy Salai, Mylapore, Chennai – 600 004, Tamil Nadu&lt;br&gt;Ms Preethy&lt;br&gt;Ph: 04441833988&lt;br&gt;<a href="mailto:preethy@swelectes.com">preethy@swelectes.com</a></td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Forbes Marshall Private Limited&lt;br&gt;A-34/35, MIDC Estate, H-Block, Pimpri, Pune – 411 016, Maharashtra&lt;br&gt;Mr Vinodra Gill&lt;br&gt;Ph: 09823103290&lt;br&gt;<a href="mailto:viii@forbessmarshall.com">viii@forbessmarshall.com</a></td>
<td>1</td>
</tr>
</tbody>
</table>
JoulePAYS
Single Pay-As-You-Save (PAYS) Agreement

Energy Savings
Guaranteed Energy Savings

Investment
0 Client Investment

Technology
Continuous Energy Optimization

Revenue
Smart Joules Gets Fixed % of Savings
How Important Are Hospitals?

9% Commercial Buildings % of Total Elec. in India

12% Hospitals % of Commercial Buildings

10 billion kWh / year

8 Million Indians
Hospitals = Ideal JoulePAYS Candidates

- Large: 100-1,000 beds; 50,000 – 200,000 m²
- Private, Urban
- 24*7
- Commercial Tariffs
- Ltd. On-Site Renewables
- 175 Target Hospitals Across India
Challenges

• Outsider Syndrome

• No Disturbances in Operating Facilities

• Changes Over Time
Learnings

• Outsider Syndrome ➔ Technology and Training

• No Disturbances in Operating Facilities ➔ Technology

• Changes Over Time ➔ Technology
Multiple benefits of energy efficiency
Sant Parmanand Hospital
USD 450K Savings in 36 Months (28%)
<table>
<thead>
<tr>
<th>Facility Name</th>
<th>Annual Energy Expenditure (INR Lakh)</th>
<th>Average Energy Savings Delivered (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sant Parmanand, Delhi</td>
<td>317</td>
<td>30%</td>
</tr>
<tr>
<td>St. Stephens, Delhi</td>
<td>640</td>
<td>24%</td>
</tr>
<tr>
<td>CMC Hospital, Ludhiana</td>
<td>714</td>
<td>22%</td>
</tr>
<tr>
<td>Shanti Mukand, Delhi</td>
<td>190</td>
<td>13%</td>
</tr>
<tr>
<td>Maharishi Ayurveda, Delhi</td>
<td>34</td>
<td>23%</td>
</tr>
<tr>
<td>Mahatma Gandhi Cancer Hospital, Vizag</td>
<td>200</td>
<td>37%</td>
</tr>
<tr>
<td>SPMM Hospital, Salem</td>
<td>100</td>
<td>21%</td>
</tr>
<tr>
<td>KIMS Hospital, Hyderabad</td>
<td>1,300</td>
<td>12% (still in execution)</td>
</tr>
<tr>
<td>G. Kuppuswamy Naidu Memorial, Coimbatore</td>
<td>1,300</td>
<td>72% (still in execution)</td>
</tr>
<tr>
<td>Fortis Hospital, Noida</td>
<td>620</td>
<td>9% (still in execution)</td>
</tr>
</tbody>
</table>
Drivers

• Operational Cost Savings

• Increased Life of Equipment = Capital Cost Savings

• Improved Reliability and Comfort

• Training for Staff

• Culture and Brand Building
Benefits

3 X 150TR Water cooled chillers

5 X 400TR Air cooled chillers

1,400TR Water cooled chillers

Fl. 9 - 15

Fl. B2 - 8

1,400TR Water cooled chillers
5 Nos. of Air Cooled Chillers of 400 TR each.
Value ~ USD 350K
4 Nos. of Secondary Pumps incl. VFDs
+ 5 Nos. of Primary Pumps (w/ electricals)
Value ~ USD 30K
2,000 sq. feet free area
Health and Wellness

- Air changes per hour
- HEPA filter cleaning
- AHU regular filter cleaning
National Energy Conservation Award

In appreciation of the achievements in Energy Conservation in the Hospital Sector for the year 2016

Government of India, Ministry of Power

is pleased to award the First Prize to

Ms. Sant Parmanand Hospital
Civil Lines (New Delhi)

Ministry of Power
New Delhi
12 December, 2016
Lessons

• Benefits Extend Far Beyond Energy Savings, But Are Hard to Determine Before-Hand

• Hospital Certification / Accreditation and Energy Efficiency Could Be Tied Together
Indicators
Indicators Used

Across Hospitals:

• kWh / m² / year
• kWh / patient / year

These are imperfect

Nature of Operations / Medical Equipment
% area air conditioned

Geography (weather)

Neighborhood (orientation, shading, etc.)
Indicators Used

For a Specific Hospital

• Energy Consumption (Monthly, Weekly, Daily, Hourly)
• Equivalent # of Households Electrified form Eliminating Energy Waste
• $\text{CO}_2\text{e}$ emissions avoided

Data Easily Available
Indicators Used
Other Indicators

For a Specific Hospital

- **Lighting**: Artificial Lighting Intensity, Prevalent Lux levels
- **Cooling**: m²/TR; kW/TR; Fresh Air %; ACPH; Thermal Comfort
- **Hot Water**: KL / patient

Can Be Measured Before & After
Other Indictors

- Maintenance Expenses
- # Breakdowns
- # Complaints
- Awareness on Energy & Environment

Data Can Be Dug Out From Records and Surveys and Constantly Monitored
<table>
<thead>
<tr>
<th>S.no.</th>
<th>Data required</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Drawings</strong></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Floor Plan (AutoCAD, PDF and hard copies)</td>
<td>To identify use areas and prepare intervention plans.</td>
</tr>
<tr>
<td>1.2</td>
<td>Ducting Layout (AutoCAD, PDF and hard copies)</td>
<td>To identify the served areas from AHUs.</td>
</tr>
<tr>
<td>1.3</td>
<td>Chilled and Cooling Water Piping Layout (AutoCAD, PDF and hard copies)</td>
<td>To identify existing piping routes, pipe sizes, and plan new routes as needed.</td>
</tr>
<tr>
<td>1.4</td>
<td>Electrical Single Line Diagram (AutoCAD, PDF and hard copy)</td>
<td>To understand load distribution, and plan for smart metering.</td>
</tr>
<tr>
<td>1.5</td>
<td>VAM Plant Room Layout(s) (AutoCAD, PDF and hard copy)</td>
<td>To plan interventions</td>
</tr>
<tr>
<td>1.6</td>
<td>Any Other AC Drawings available</td>
<td>To plan interventions</td>
</tr>
<tr>
<td>2</td>
<td><strong>Assets list</strong></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Bio-medical Equipments (with kW ratings)</td>
<td>To be included in Exhibit B</td>
</tr>
<tr>
<td>2.2</td>
<td>AHUs, FCUs, TFAs with Design details (CFM, kW, TR) and location</td>
<td>To plan interventions in the HVAC system</td>
</tr>
<tr>
<td>2.3</td>
<td>Split/Window/Ductable/Other Unitary ACs (preferably location-wise, if available)</td>
<td>To plan interventions in the AC system</td>
</tr>
<tr>
<td>2.4</td>
<td>Indoor and Outdoor Lights, Ceiling Fans and Exhaust Fans</td>
<td>To plan Lighting and Fan retrofits, as appliable</td>
</tr>
<tr>
<td>2.5</td>
<td>Raw Water Pumps</td>
<td>To plan pumping retrofits</td>
</tr>
<tr>
<td>2.6</td>
<td>Laundry Equipment</td>
<td>To plan steam system retrofits, as appliable</td>
</tr>
<tr>
<td>S.no.</td>
<td>Data required</td>
<td>Remarks</td>
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<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>2.7</td>
<td>CSSD Equipment (sterilizers and boilers)</td>
<td>To plan steam system retrofits, as appliable</td>
</tr>
<tr>
<td>2.8</td>
<td>Kitchen Equipment (boilers, burners, deep freezers, etc.)</td>
<td>To plan kitchen retrofits, as appliable</td>
</tr>
<tr>
<td>3</td>
<td>Reports</td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>Previous Energy Audit Reports (TERI and others)</td>
<td>To get a head start in prioritizing interventions</td>
</tr>
<tr>
<td>3.2</td>
<td>Water Quality Testing Reports (Raw Water, treated STP water and Cooling Tower Water)</td>
<td>To plan interventions in the HVAC system</td>
</tr>
<tr>
<td>3.3</td>
<td>Internal Engineering and Maintenance Monthly Reports for Last 12 months</td>
<td>These will have a lot of the data we will need to design our interventions</td>
</tr>
<tr>
<td>4</td>
<td>Equipment Design Documents / Brochures</td>
<td></td>
</tr>
<tr>
<td>4.1</td>
<td>VAM Chillers</td>
<td></td>
</tr>
<tr>
<td>4.2</td>
<td>Pumps</td>
<td></td>
</tr>
<tr>
<td>4.3</td>
<td>Boilers</td>
<td>To assess sizing, design efficiencies, find best operating points, and interface with software</td>
</tr>
<tr>
<td>4.4</td>
<td>VFDs</td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td>BMS</td>
<td></td>
</tr>
<tr>
<td>4.6</td>
<td>CSSD Sterilizers and Boilers</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Engineering Records (preferably Excel files with 12 months of data)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Information / Documentation Needed from GKNMH</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Engineering Records (preferably Excel files with 12 months of data)</td>
<td></td>
</tr>
<tr>
<td>5.1</td>
<td>Energy Metering Logs</td>
<td></td>
</tr>
<tr>
<td>5.2</td>
<td>Chiller Plant Logs</td>
<td></td>
</tr>
<tr>
<td>5.3</td>
<td>Temperature Logs</td>
<td></td>
</tr>
<tr>
<td>5.4</td>
<td>Complaint Logs</td>
<td></td>
</tr>
</tbody>
</table>

5.2 Chiller Plant Logs

To find inefficiencies and problem areas that can be addressed as part of the efficiency retrofit

6 | Adjustments |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td>New equipment added since Jan. 2017</td>
</tr>
<tr>
<td>6.2</td>
<td>Equipment removed since Jan. 2017</td>
</tr>
<tr>
<td>6.3</td>
<td>Note on change in use of any area in the Hospital since Jan. 2017</td>
</tr>
<tr>
<td>6.4</td>
<td>List of areas within facility that are billed separately for their energy consumption</td>
</tr>
</tbody>
</table>
Lessons

• Collecting Data is Not Easy and Time Consuming

• Spending Extra Time & Effort Up-front Is Always a Good Idea to Unambiguously Establish the Value of Eliminating Energy Waste
Implementation
Sign JoulePAYS Agreement

Smart Joules completes Assessment, Development, Financing and Execution of All Major Retrofits

Continuous Energy Management by Smart Joules

Equipment ownership transfers to Hospital at no cost
NOW, THEREFORE, the Parties, intending to be legally bound, covenant and agree as follows:

1. **Contractor Obligations**
   
   i. Complete energy saving project design and implementation at its own cost within a period of nine months.
   
   ii. Provide maintenance on all new equipment supplied and installed by Contractor throughout the Term.
   
   iii. Deliver monthly invoices outlining energy savings delivered and Contractor's share of savings ("Monthly Services Fees") throughout the Term.
   
   iv. Provide adequate training to Customer's engineering team such that they can adequately operate, troubleshoot and maintain the equipment and Measures.

2. **Customer Obligations**
10. **Contractor’s Assurance**

Starting on the Completion Date and throughout the Term, Contractor guarantees delivering 10% energy savings on an annual basis compared to the sum of Baseline Monthly Energy Consumption. Contractor hereby agrees to fully reimburse Customer for a shortfall in Energy Cost Savings Sharing delivered over the previous year (the “Shortfall Amount”). The Shortfall Amount, if any, shall be computed by the Contractor or by the Third Party, and shall be explicitly stated as part of each Annual Report in order for the Customer to claim reimbursement.
Where Do Hospitals Consume Energy?

- Chillers & Cooling Towers for Central Air Conditioning, 30%
- Medical Equipment, 20%
- Hot Water Generation, 10%
- Ventillation (AHUs, FCUs, TFAs, Fans), 9%
- HVAC Pumps, 9%
- Lighting, 9%
- Others (STP, Refrigeration, ...), 30%
Continuous Oversight and Active Management

VFDs

Energy Manager + Staff Training

LED Lighting

Cooling & Heating Optimization

IE3/EC Motors

Automation

BLDC Fans
<table>
<thead>
<tr>
<th>S.No.</th>
<th><strong>Energy Conservation Measure</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Chillers</em></td>
</tr>
<tr>
<td>a</td>
<td>Load Consolidation</td>
</tr>
<tr>
<td>b</td>
<td>New Chiller(s)</td>
</tr>
<tr>
<td>c</td>
<td>Run hour optimization</td>
</tr>
<tr>
<td>d</td>
<td>Chilled water set point optimization</td>
</tr>
<tr>
<td>e</td>
<td>Chiller sequencing</td>
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<tr>
<td>f</td>
<td>Descaling</td>
</tr>
<tr>
<td>g</td>
<td>Reducing Condenser Approach with ATCS</td>
</tr>
<tr>
<td>h</td>
<td>Reducing Condenser Approach with Water Quality Improvement</td>
</tr>
<tr>
<td>i</td>
<td>Evaporative Cooling Pads for Air Cooled Chillers</td>
</tr>
<tr>
<td>j</td>
<td>DeJoule</td>
</tr>
<tr>
<td>2</td>
<td><em>HVAC Pumps</em></td>
</tr>
<tr>
<td>a</td>
<td>New Pumps - Chilled Water</td>
</tr>
<tr>
<td>b</td>
<td>New Pumps - Condenser Water</td>
</tr>
<tr>
<td>c</td>
<td>Optimizing Chilled Water Flow - Dynamic with VFDs</td>
</tr>
<tr>
<td>d</td>
<td>Optimizing Chilled Water Flow - One time</td>
</tr>
<tr>
<td>e</td>
<td>Optimizing Condenser Water Flow - Dynamic with VFDs</td>
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<tr>
<td>f</td>
<td>Optimizing Condenser Water Flow - One time</td>
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<td>g</td>
<td>Run hour optimization</td>
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<td>h</td>
<td>DeJoule</td>
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<td>S.No.</td>
<td>Energy Conservation Measure</td>
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<td>--------------------------------------------------</td>
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<tr>
<td>3</td>
<td><strong>Cooling Towers</strong></td>
</tr>
<tr>
<td>a</td>
<td>New Cooling Tower</td>
</tr>
<tr>
<td>b</td>
<td>Fill Replacement</td>
</tr>
<tr>
<td>c</td>
<td>Nozzle Cleaning</td>
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<tr>
<td>d</td>
<td>Motor Replacement</td>
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<td>e</td>
<td>VFD Installation</td>
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<tr>
<td>f</td>
<td>Run hour optimization</td>
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<td>g</td>
<td>DeJoule</td>
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<tr>
<td>4</td>
<td><strong>Low Side Optimization</strong></td>
</tr>
<tr>
<td>a</td>
<td>Water Flow Balancing</td>
</tr>
<tr>
<td>b</td>
<td>Air Flow Balancing</td>
</tr>
<tr>
<td>c</td>
<td>VFDs for Air Flow Optimization</td>
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<tr>
<td>d</td>
<td>Valves for Water Flow Optimization</td>
</tr>
<tr>
<td>e</td>
<td>Run-hour Optimization</td>
</tr>
<tr>
<td>f</td>
<td>Set Point Rationalization</td>
</tr>
<tr>
<td>g</td>
<td>Damper Controls for Different Areas Fed by Same AHU</td>
</tr>
<tr>
<td>h</td>
<td>Motor Replacement</td>
</tr>
<tr>
<td>i</td>
<td>Removal of Heating Coils</td>
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<td>j</td>
<td>Pulley Size Optimization</td>
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<td>k</td>
<td>Fresh Air % Optimization</td>
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<td>S.No.</td>
<td>Energy Conservation Measure</td>
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<td>l</td>
<td>Heat Recovery Wheels</td>
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<td>m</td>
<td>PHE for Recovery of Exhaust Cooling</td>
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<td>n</td>
<td>Descaling Cooling Coils</td>
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<td>o</td>
<td>Changing to EC Fans</td>
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<td>p</td>
<td>DeJoule</td>
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<tr>
<td>5</td>
<td><strong>Heat Load Reduction</strong></td>
</tr>
<tr>
<td>a</td>
<td>Cool Roof Paint</td>
</tr>
<tr>
<td>b</td>
<td>Films on Windows</td>
</tr>
<tr>
<td>c</td>
<td>Plugging Air Leakages from End-Use Areas</td>
</tr>
<tr>
<td>d</td>
<td>Eliminating Mixing of Supply Air with Other Air Streams</td>
</tr>
<tr>
<td>e</td>
<td>Insulation of Ducts, Pipelines and Other Areas</td>
</tr>
<tr>
<td>f</td>
<td>Shading of Outdoor AC Units</td>
</tr>
<tr>
<td>g</td>
<td>Using Door Closers to Prevent Hot Air Entering / Cool Air Escaping</td>
</tr>
<tr>
<td>h</td>
<td>Using Air Curtains to Prevent Hot Air Entering / Cool Air Escaping</td>
</tr>
<tr>
<td>6</td>
<td><strong>Consolidating Cooling Load</strong></td>
</tr>
<tr>
<td>a</td>
<td>Aux. Air Cooled Chiller</td>
</tr>
<tr>
<td>b</td>
<td>Split and Window ACs</td>
</tr>
<tr>
<td>7</td>
<td><strong>LED Lighting</strong></td>
</tr>
<tr>
<td>8</td>
<td><strong>BLDC Fans</strong></td>
</tr>
<tr>
<td>9</td>
<td><strong>UPS Load Consolidation</strong></td>
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<tr>
<td>S.No.</td>
<td>Energy Conservation Measure</td>
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<tr>
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<td>---------------------------------------------</td>
</tr>
<tr>
<td>9</td>
<td><strong>UPS Load Consolidation</strong></td>
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<tr>
<td>10</td>
<td><strong>DeJoule</strong></td>
</tr>
<tr>
<td></td>
<td>a</td>
</tr>
<tr>
<td></td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>C</td>
</tr>
<tr>
<td>11</td>
<td><strong>Raw Water Pumps</strong></td>
</tr>
<tr>
<td></td>
<td>a</td>
</tr>
<tr>
<td></td>
<td>b</td>
</tr>
<tr>
<td>12</td>
<td><strong>Automation</strong></td>
</tr>
<tr>
<td></td>
<td>a</td>
</tr>
<tr>
<td></td>
<td>b</td>
</tr>
<tr>
<td></td>
<td>c</td>
</tr>
<tr>
<td></td>
<td>d</td>
</tr>
<tr>
<td></td>
<td>e</td>
</tr>
<tr>
<td></td>
<td>f</td>
</tr>
<tr>
<td>13</td>
<td><strong>Laundry</strong></td>
</tr>
<tr>
<td></td>
<td>a</td>
</tr>
<tr>
<td></td>
<td>b</td>
</tr>
<tr>
<td>S.No.</td>
<td>Energy Conservation Measure</td>
</tr>
<tr>
<td>-------</td>
<td>------------------------------------------------------------------</td>
</tr>
<tr>
<td>c</td>
<td>Improvements in Insulation</td>
</tr>
<tr>
<td>d</td>
<td>Steam Trap Health Improvement</td>
</tr>
<tr>
<td>e</td>
<td>Laundry Load Consolidation</td>
</tr>
<tr>
<td>14</td>
<td><strong>Kitchen</strong></td>
</tr>
<tr>
<td>a</td>
<td>Proper Cleaning of Burners</td>
</tr>
<tr>
<td>b</td>
<td>Replacement with Agnisumukh Burners</td>
</tr>
<tr>
<td>15</td>
<td><strong>Domestic Hot Water</strong></td>
</tr>
<tr>
<td>a</td>
<td>Boiler Replacement</td>
</tr>
<tr>
<td>b</td>
<td>Heat Pump Installation to Replace Boiler / Geysers / Elec. Heating</td>
</tr>
<tr>
<td>c</td>
<td>Tank Size Optimization</td>
</tr>
<tr>
<td>d</td>
<td>Solar Hot Water System</td>
</tr>
<tr>
<td>e</td>
<td>Collection and Utilization of Condensate / Waste Hot Water</td>
</tr>
<tr>
<td>f</td>
<td>Run Hour Optimization</td>
</tr>
<tr>
<td>g</td>
<td>Set Point Rationalization</td>
</tr>
<tr>
<td>16</td>
<td><strong>Power Factor Improvement</strong></td>
</tr>
<tr>
<td>a</td>
<td>Capacitor Panel Installation at LT Panel</td>
</tr>
<tr>
<td>b</td>
<td>Capacitor Installation at Load-level</td>
</tr>
<tr>
<td>17</td>
<td><strong>Space Heating Optimization</strong></td>
</tr>
<tr>
<td>a</td>
<td>Using Heat Pump for Hot Water Generation (Centralized Systems)</td>
</tr>
<tr>
<td>b</td>
<td>Higher Efficiency Unitary Heaters</td>
</tr>
<tr>
<td>S.No.</td>
<td>Energy Conservation Measure</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>c</td>
<td>Low Speed Fans for Better Heating Distribution</td>
</tr>
<tr>
<td>18</td>
<td><strong>CSSD</strong></td>
</tr>
<tr>
<td>a</td>
<td>Use Dedicated Electric Boiler Instead of Centralized</td>
</tr>
<tr>
<td>b</td>
<td>Increase Boiler Feed Water Temperature</td>
</tr>
<tr>
<td>19</td>
<td><strong>Gas Manifold / Compressors</strong></td>
</tr>
<tr>
<td>20</td>
<td><strong>Biomedical Equipment</strong></td>
</tr>
<tr>
<td>21</td>
<td><strong>STPs</strong></td>
</tr>
<tr>
<td>a</td>
<td>Blower Replacement</td>
</tr>
<tr>
<td>b</td>
<td>Pump Replacement</td>
</tr>
<tr>
<td>c</td>
<td>VFD</td>
</tr>
<tr>
<td>d</td>
<td>Reducing Amount of Wastewater</td>
</tr>
<tr>
<td>22</td>
<td><strong>Exhaust Fans</strong></td>
</tr>
<tr>
<td>a</td>
<td>Temperature Controllers</td>
</tr>
<tr>
<td>23</td>
<td><strong>Other Operational Efficiency Improvements</strong></td>
</tr>
<tr>
<td>a</td>
<td>Transformer Load Consolidation</td>
</tr>
<tr>
<td>b</td>
<td>Remove / Consolidate Stabilizers</td>
</tr>
<tr>
<td>c</td>
<td>Arrest Ghost Loads</td>
</tr>
<tr>
<td></td>
<td>Baseline</td>
</tr>
<tr>
<td>----------------</td>
<td>-------------------</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Pump ref</td>
<td></td>
</tr>
<tr>
<td>Flow m³/hr</td>
<td>85</td>
</tr>
<tr>
<td>Head m</td>
<td>24</td>
</tr>
<tr>
<td>Power kW</td>
<td>11.02</td>
</tr>
<tr>
<td>Efficiency %</td>
<td>38%</td>
</tr>
<tr>
<td>SEC kWh/m³</td>
<td>0.13</td>
</tr>
<tr>
<td>Operation Hrs hrs</td>
<td>0.00</td>
</tr>
<tr>
<td>Annual days</td>
<td>274.17</td>
</tr>
<tr>
<td>Annual kWh</td>
<td>81,111</td>
</tr>
<tr>
<td>Energy Cost Rs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Savings Rs</td>
<td></td>
</tr>
<tr>
<td>Payback years</td>
<td></td>
</tr>
<tr>
<td>5 yr Savings Rs</td>
<td></td>
</tr>
</tbody>
</table>
Overview:

Condenser pumps of water cooled chillers circulate flow between cooling towers and chillers. The flow and the efficiency of the pumps impact the efficiency (kW/TK) of the HVAC system. The challenge for a well-engineered, operated and maintained HVAC pumping system is to reliably maintain adequate flow and pressure (head) based on dynamic chiller loading while minimizing energy losses.

This note summarizes Smart Joules’ findings with regards to specifications and efficiency of the existing HVAC pumping system at KIMS Secunderabad, and our planned interventions to improve efficiency and reliability while reducing maintenance requirements of the system.

Existing HVAC Pumping System:

There are 5 Nos. of condenser pumps of 25 HP each. In practice, for every one chiller in operation, one condenser pump is operated. In peak cooling load conditions, three chillers are switched ON along with three condenser pumps, and the balance two pumps are kept as standby.

Smart Joules audited the performance of the running pumps using ultra sonic flow meter and power logger, and the overall efficiency of the pump was arrived by using the following formula:

Efficiency (%) =
Chilled water flow (SPM)*Delta pressure in meters of WC/360* Power Consumption*100%

Table 1: Performance of Condenser Pumps

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit</th>
<th>Design</th>
<th>Pump 1</th>
<th>Pump 2</th>
<th>Pump 3</th>
<th>Pump 4</th>
<th>Pump 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>m³/hr</td>
<td>170</td>
<td>157</td>
<td>127</td>
<td>140</td>
<td>136</td>
<td>130</td>
</tr>
<tr>
<td>Head</td>
<td>m</td>
<td>24</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Hydraulic Power Output</td>
<td>KW</td>
<td>9.5</td>
<td>15.4</td>
<td>15.3</td>
<td>15.7</td>
<td>14.9</td>
<td></td>
</tr>
<tr>
<td>Power Consumption</td>
<td>KW</td>
<td>18.5</td>
<td>11.02</td>
<td>17.93</td>
<td>17.66</td>
<td>17.28</td>
<td>17.28</td>
</tr>
<tr>
<td>Power Factor</td>
<td>PF</td>
<td>0.88</td>
<td>0.86</td>
<td>0.84</td>
<td>0.84</td>
<td>0.84</td>
<td>0.84</td>
</tr>
<tr>
<td>Overall Efficiency</td>
<td>%</td>
<td>42%</td>
<td>42%</td>
<td>42%</td>
<td>42%</td>
<td>42%</td>
<td>42%</td>
</tr>
</tbody>
</table>

Smart Joules’ condition and performance assessment of these pumps shows that:

- The pumps are delivering significantly lower flow than the design values. Thus, the required flow to provide chiller condenser cooling is not provided by these underperforming pumps.
- These pumps are provided with star-delta starters. Therefore, their starting current is high, which adds stress on the electrical systems and reduces their useful life.
- Overall operating efficiencies of these pumps are very low.

Overall, it is clear from our performance and condition assessment that these assets are worn out and are not allowing for optimal chiller plant performance.

Proposed System:

Smart Joules plans to replace two new premium efficiency condenser pumps with in-built Variable Frequency Drives (VFD) and higher flow capacity. With the introduction of the new energy efficient VFD pumps, the required water flow and pressure levels will be achieved and the power consumption will be low. Design parameters of the new energy efficient pumps are as follows:

Table 2: Design Parameters of Proposed Condenser Pumps

<table>
<thead>
<tr>
<th>Make</th>
<th>Condenser Water Pumps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make</td>
<td>Armstrong</td>
</tr>
<tr>
<td>Quantity</td>
<td>2</td>
</tr>
<tr>
<td>Flow (gpm)</td>
<td>2,000</td>
</tr>
<tr>
<td>Head (m)</td>
<td>24</td>
</tr>
<tr>
<td>Power Consumption at Design (KW)</td>
<td>25.6</td>
</tr>
<tr>
<td>Motor Rating (KW)</td>
<td>30</td>
</tr>
<tr>
<td>Speed (rpm)</td>
<td>1,400</td>
</tr>
<tr>
<td>Frequency (Hz)</td>
<td>47</td>
</tr>
<tr>
<td>Efficiency (%)</td>
<td>85.95</td>
</tr>
</tbody>
</table>
Reasoning Behind Selection:

Smart Joules carefully selects the high-efficiency equipment we install at our customer sites. We considered the following points to arrive at our final selection of Armstrong Sensorless Design-Envelope pumps:

- **Manufacturer**: Armstrong has world-leading expertise in fluid flow, heat transfer, variable speed, and demand-based control. They are the most advanced, renowned and proven supplier of HVAC pumps across the world.
- **Pump type**: Smart Joules has chosen the highest end of Armstrong's offerings: design envelope 4200H split-coupled horizontal end-suction pumps. These pumps have onboard intelligent Variable Speed controls with Sensorless control. This eliminates the requirement of installation of flow meters, VFDs and additional sensing devices.
- **Material of construction**: These pumps have bronze impellers, which prevent cavitation and pulsating-related issues that are common in other types of impellers. They have high-quality cast-iron casing, which reduces frictional losses. They also have stainless steel mechanical seals, which prevent water and frictional losses.
- **Duty points**: Smart Joules has selected these pumps based on an analysis of their performance and capabilities at various duty points (operational conditions) that are expected to occur on site. We have considered the performance of the chillers and other cooling equipment. Please refer to intended operational logic section below for further details.
- **Controllability**: These pumps have embedded systems capable of communicating with external controllers over standard open communication protocols (MODBUS / BACNET). This feature is an essential part of modern HVAC plants, and will be utilized by Smart Joules to monitor and control the pumps.
- **Maintenance and Service**: These pumps have nearly maintenance-free design, as they do not use glands, use high quality seals and superior materials. Further, the mono-block design ensures there are no alignment issues. Finally, service support is provided by a highly professional group of service engineers, and spares are readily available locally in India.
- **Performance**: The design, materials of construction and integrated variable speed control features of these pumps ensure that they are the most energy efficient pumps available for this purpose. Further, they have minimal performance deterioration over time.

Intended Operational Logic:

Pump selection is done by Smart Joules with the following principles:

- Flow and pressure should be maintained as needed across a wide range of operational scenarios without affecting occupant comfort.
- Energy efficiency should be high across all operating scenarios that are expected to occur with reasonable frequency.

Our detailed assessment across expected operational conditions at KIMS after pump replacement and associated pump performance parameters is as follows:

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Operating Conditions</th>
<th>Flow (GPM)</th>
<th>Head (ft)</th>
<th>Freq. (Hz)</th>
<th>Power (kW)</th>
<th>Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>When two chillers are operated, two new condenser pumps will be operated in lower frequency.</td>
<td>1153</td>
<td>18</td>
<td>39.9</td>
<td>15.12</td>
<td>85.80</td>
</tr>
<tr>
<td>Maximum Load</td>
<td>When three chillers are operated, two new condenser pumps will be operated at high frequency.</td>
<td>1500</td>
<td>24</td>
<td>47</td>
<td>25.62</td>
<td>86.95</td>
</tr>
<tr>
<td>Minimum Load</td>
<td>When one chiller is operated, one new condenser pump will be operated in lower frequency.</td>
<td>1153</td>
<td>18</td>
<td>39.9</td>
<td>15.1</td>
<td>85.80</td>
</tr>
</tbody>
</table>

Table 3: Operation Logic of Condenser Pump

Performance curves of the selected pumps are provided herein below:
Anticipated Benefits for KIMS:

- Lower energy costs on account of top-of-the-line energy efficient pumps;
- Improvement in flow and pressure, contributing to overall improvement in chiller loading and efficiency;
- New technology: The new pumps will be connected to the BMS for analysis and optimization. This continuous monitoring of pump performance will ensure optimum efficiency and reliable operations;
- Greater reliability with new machines;
- Updated operational practices and manpower training;
- Reduced OPEX since 2-3 of the existing condenser pumps that are replaced could be moved to other sites;
- Reduced maintenance and repair costs.

SIPL Responsibilities:

- System re-design and new equipment selection to ensure greater energy efficiency and reliability;
- Placing purchase and work orders for the shortlisted equipment;
- Dismantling and disposal of redundant pumps that are replaced with new pumps;
- Co-ordination with vendors for delivery, installation and commissioning activities, including all foundation, mechanical and electrical connections;
- Provision of Efficient Operating Procedures to KIMS at the time of commissioning and training to KIMS’s manpower on efficient operational practices;
- Performance monitoring and continuous optimization of new pumps;
- Preventive, regular and breakdown maintenance throughout the contract duration.

KIMS Responsibilities:

- Provide storage space for the new pumps when received on site;
- Ensure that existing pumps that are retained as back-up continue to be maintained properly so that these can be used if and when needed;
- Operate the system as per procedures prescribed by Smart Joules with inputs from OEMs;
- A complete chiller plant shut-down will be required for 4-6 hours for piping fabrications works;
- Continue existing maintenance & documentation practices or additionally suggested by Smart Joules within the same resources.

ECM Timeline:

The purchase order will be placed immediately upon getting confirmation signature below, and the lead time for delivery on site will be 10-12 weeks. Installation activities will take another week.

---

Declaration by KIMS:

We hereby declare that we support Smart Joules’ selection and give our approval to Smart Joules Private Limited to place the purchase / work order(s) for execution of the same at KIMS.

Signature: __________________________

Name: Mr. V. V. Suresh

Designation: DGM, Engineering Maintenance

Krishna Institute of Medical Science
No. 1-B-31/L, Minister Road,
Krishna Nagar Colony, Begumpet,
Secunderabad,
Telangana 500003

Figure 3: Performance Curve of Condenser Water Pumps
Reliable & Secure
system capable of monitoring and controlling anything from anywhere at anytime

Universal Compatibility
enhancing capabilities of existing systems

Scalable & Redundant
architecture with distributed computation and memory

Aesthetics for Wow
good looking hardware and user interface

Joule Recipes
to enable network effects in efficiency by aggregating collective industry intelligence

Self Diagnostics
for minimum maintenance and down time

Intuitive, Interactive
and cross-platform design to draw in human participation

Joule Mind
for evolutionary intelligence based on data

Color coding stages for phase of development:
- Delivered
- Under development
- Planned
Efficient Operational Procedures

1. Operating OT AHUs at reduced frequency in Night:

There are already 3 nos. of OT AHUs that have VFDs installed with them and also there are 3 nos. un-commissioned VFDs in OT AHU room. SJPL is going to install these three VFDs at OT AHUs. Currently all installed VFDs are being run at constant frequency for 24x7 hours while OTs are occupied only in day time. We can close the OT AHUs for night time as there is no cooling requirement at that time, and can be switched on for emergency cases. These AHUs can achieve the desired temperature in 10 minutes. We recommend to switch off the OT AHUs in night or at least use at reduced frequency of 30Hz in nights (time 10:00PM to 6:00AM). The list of these AHUs is provided in Table 1 below. Initially frequency needs to be reduced manually in night and then increase in morning by Fortis Operators. In future, when SJPL will be installing its own BMS controls, then the same shall be carried out with Smart Joules BMS.

Table 1: OT AHUs to be operated at 30Hz at Night Times

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>AHUs location</th>
<th>Airflow (CFM)</th>
<th>Rated KW</th>
<th>Current Operating frequency</th>
<th>Day time avg. temp.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OT-1</td>
<td>3000 CFM</td>
<td>3.7</td>
<td>50 Hz for whole day</td>
<td>19.5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>OT-2</td>
<td>4000 CFM</td>
<td>3.7</td>
<td>50 Hz for whole day</td>
<td>19.4</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>OT-3</td>
<td>3000 CFM</td>
<td>3.7</td>
<td>Un-commissioned</td>
<td>17.7</td>
<td>SJPL planning to commission the un-commissioned VFDs</td>
</tr>
<tr>
<td>4</td>
<td>OT-4</td>
<td>3000 CFM</td>
<td>3.7</td>
<td>Un-commissioned</td>
<td>18.6</td>
<td>SJPL planning to commission the un-</td>
</tr>
</tbody>
</table>
Term Loan

YES Bank

Loan Guarantee

SIDBI

Partial Risk Sharing Facility

The World Bank
Who Wins?

- 10,000 + Households
- Hospitals
- Smart Joules
Lessons

• Energy efficiency can be more powerful than renewables
• Make eliminating energy waste simple (ESCO model)
• Technology is needed for scale
Arjun P. Gupta, Founder & CEO
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