# 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***

Massachusetts Institute of Technology

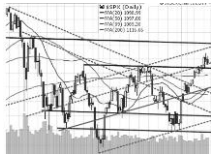
Champions of Change



**Ujjal Majumdar,** ***COO***



**Sidhartha Gupta,** ***CFO***



## Team

**50**
100% YoY Growth

**17** Product Development

**7** Central Resources

**8** Project Design & Execution

**6** Product Deployment

**5** Product Testing and Utilization

**7** Maintenance

## Core Values

Empower Each Team Member with a **Sense of Ownership**

Pursue **Growth and Learning**

**Get Shit Done**

Be **Adventurous**, Creative and Open-minded

Build a Positive **Team and Family Spirit**

Be **Passionate**, Determined and Bold

Maintain a High Level of **Transparency and Honesty**

Ministry of Power, Government of India — National Energy Conservation Award

CII Confederation of Indian Industry — National Award for Excellence in Energy

Hello Tomorrow — Top 100 Technology Startups in the World

The Economic Times

BW Businessworld

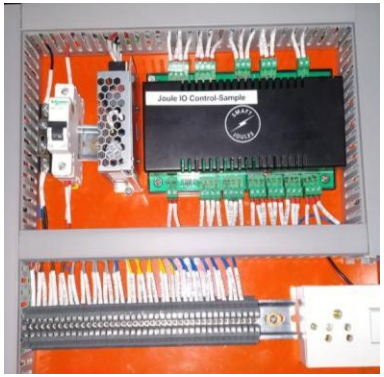
The Huffington Post

iea — International Energy Efficiency Expert

UNYCC — Young Changemaker

ADB — Top 20 Asian Clean Energy Entrepreneurs


LUDHIANA CHRISTIAN MEDICAL COLLEGE
Maharishi Ayurveda®
Fortis HOSPITALS
SANT PARMANAND HOSPITAL
multi super speciality hospital
ISO 9001:2008
Healing Hand
SMH
Shanti Mukand Hospital
KIMS HOSPITALS™
Mahatma Gandhi
Cancer Hospital & Research Institute
Giving hope, celebrating life...
S.PALANIANDI MUDALIAR
MEMORIAL HOSPITAL
Passionate about growth
Compassionate about people
ESTD 1962


Joule IO Control-Sample


JOULE IO CONTROLLER-7



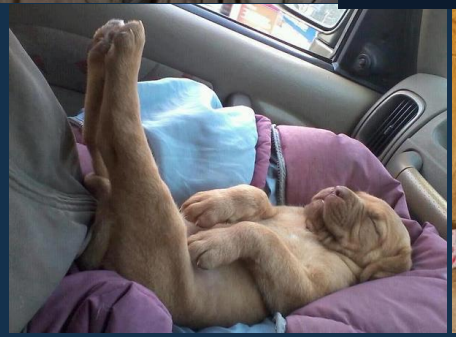


# How Important is Eliminating Energy Waste?



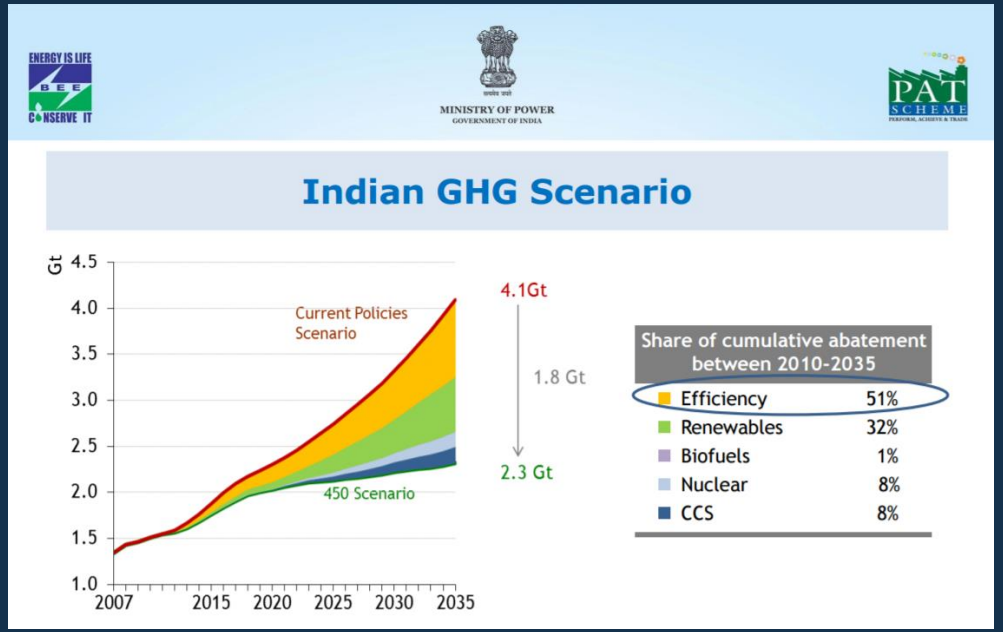








# How Important is Eliminating Energy Waste?




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?

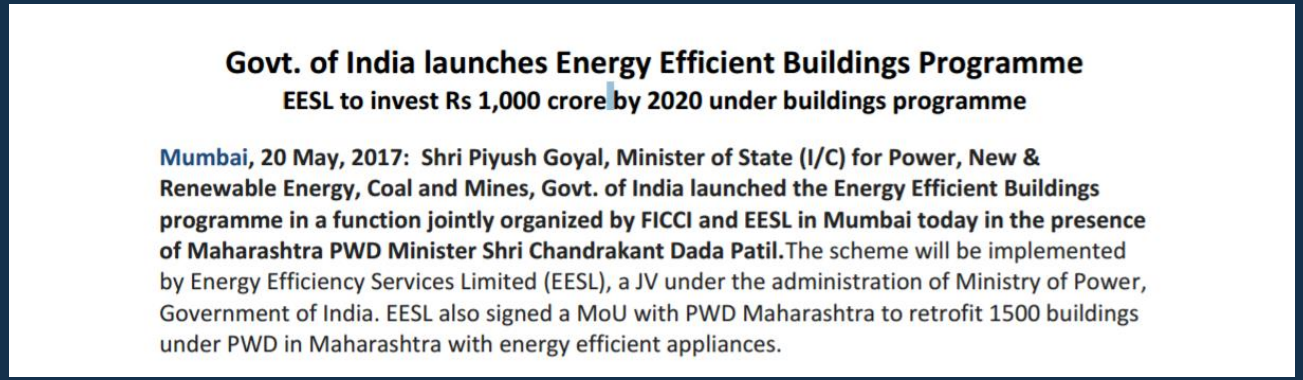


**Indian government looks to save Rs 35,000 crore by making buildings energy efficient**

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?



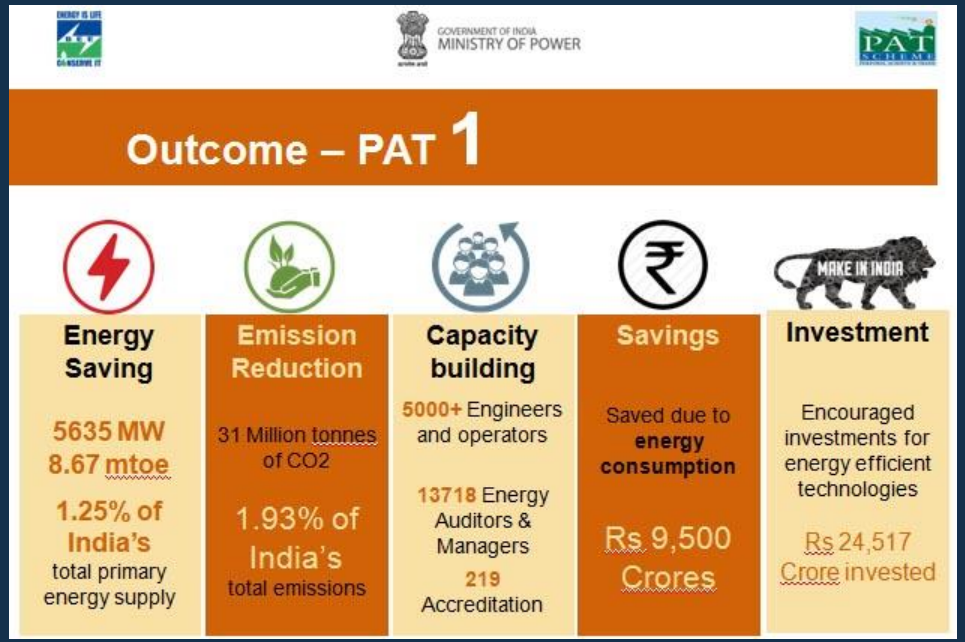
**Govt. of India launches Energy Efficient Buildings Programme**

**EESL to invest Rs 1,000 crore by 2020 under buildings programme**

**Mumbai, 20 May, 2017: Shri Piyush Goyal, Minister of State (I/C) for Power, New & Renewable Energy, Coal and Mines, Govt. of India launched the Energy Efficient Buildings programme in a function jointly organized by FICCI and EESL in Mumbai today in the presence of Maharashtra PWD Minister Shri Chandrakant Dada Patil.** The scheme will be implemented by Energy Efficiency Services Limited (EESL), a JV under the administration of Ministry of Power, Government of India. EESL also signed a MoU with PWD Maharashtra to retrofit 1500 buildings under PWD in Maharashtra with energy efficient appliances.

FICCI Press Release (20th May '17) and Business Standard (23rd May, 2017)
on launch of the Energy Efficient Buildings Programme by Minister Piyush Goyal in Mumbai
http://ficci.in/pressrelease/2771/ficci-press-release-may20-energy.pdf
http://www.business-standard.com/article/news-cm/govt-of-india-launches-energy-efficient-buildings-programme-eesl-to-invest-rs-1-000-crore-by-2020-under-buildings-programme-117052301686_1.html

# What Is the Indian Government Doing?




Bureau of Energy Efficiency Website:
https://www.beeindia.gov.in/content/pat-3



LBNL-3381E

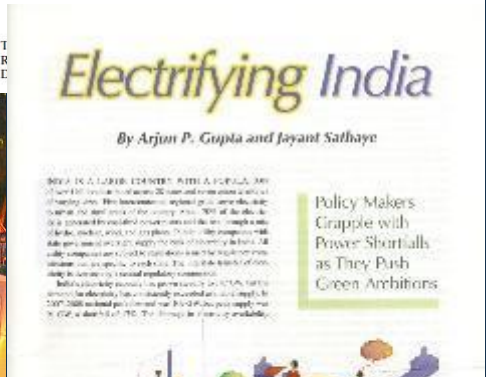
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

# 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**



JAYPEE GROUP

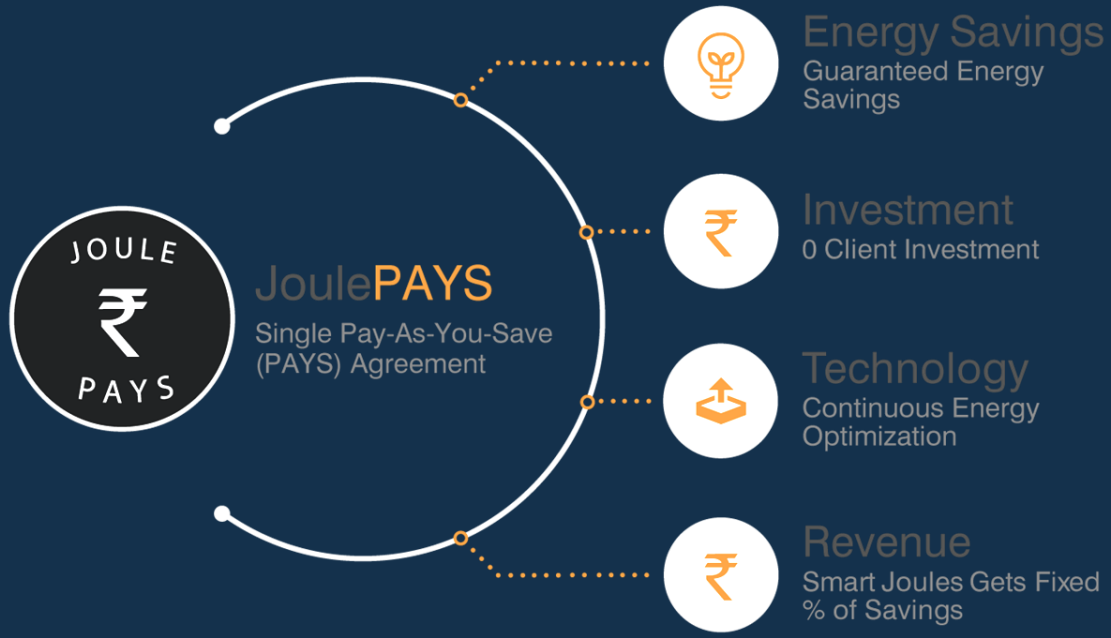


- Cement
- Fertilizer
- Hotels
- Hospitals
- Universities
- Formula 1

## Bureau of Energy Efficiency (BEE) empanelled ESCOs (129 Nos.)

**A. List of 94 Energy Service Companies (ESCOs) empanelled with BEE with validity till 30th March, 2017**

| S. No. | Name of Organization | Grade |
|---|---|---|
| 1 | **Ingersoll Rand Climate Solutions Private Limited**<br>Plot No.35, KIADB Industrial Area, Bidadi, Bengaluru – 562 109, Karnataka<br><br>**Mr Gopi Krishna**<br>Ph: 09535611688<br>Gopi.Javvaji@irco.com | 1 |
| 2 | **Schneider Electric India Private Limited**<br>4th Floor, Electra wing A, Exora Business Park, Marathahalli, Sarjapur Outer Ring Road, Bangalore – 560103, Karnataka<br><br>**Ms Bindu Thomas**<br>Ph: 09980549982<br>bindu.Thomas@schneider-electric.com | 1 |
| 3 | **Salzer Electronics Limited**<br>Samichettipalayam (PO), Jothipuram (Via), Coimbatore – 641 047, Tamil Nadu<br><br>**Mr Sathishkumar**<br>Ph: 09500922351<br>sathishkumar@schnellenergy.com | 1 |
| 4 | **Swelect Energy Systems Limited**<br>Numeric House, 3rd Floor, Number 5, Sir P S Sivasamy Salai, Mylapore, Chennai – 600 004, Tamil Nadu<br><br>**Ms Preethy**<br>Ph: 09944185399<br>preethy.c@swelectes.com | 1 |
| 5 | **Forbes Marshall Private Limited**<br>A-34/35, MIDC Estate, H-Block, Pimpri, Pune – 411 018, Maharashtra<br><br>**Mr Virendra Gill**<br>Ph: 09823104290<br>vgill@forbesmarshall.com | 1 |



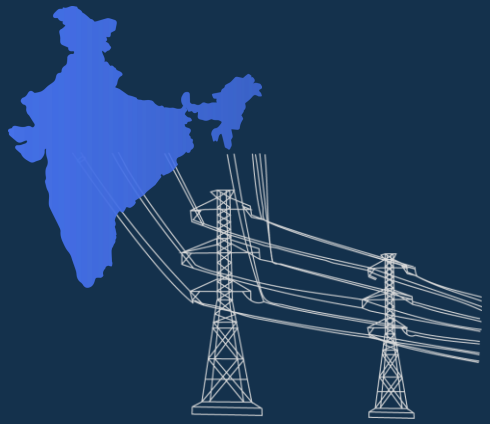

the David & Lucile Packard FOUNDATION

ECHOING GREEN

HARVARD UNIVERSITY SOUTH ASIA INSTITUTE

TATA TRUSTS

# How Important Are Hospitals?



9%

Commercial Buildings % of Total Elec. in India

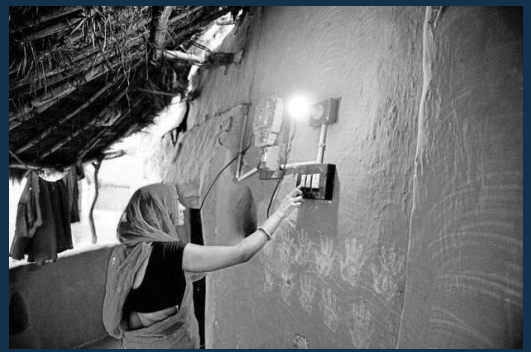


12%

Hospitals % of Commercial Buildings

10 billion kWh / year

=



8 Million Indians

# Hospitals = Ideal JoulePAYS Candidates

- Large: 100-1,000 beds; 50,000 – 200,000 $m^2$
- Private, Urban
- 24*7
- Commercial Tariffs
- Ltd. On-Site Renewables
- 175 Target Hospitals Across India


INDIA'S LEADING
ENERGY EFFICIENT HOSPITAL
ONN
TOTAL COMFORT


ST. STEPHEN'S HOSPITAL H


KIMS HOSPITALS






# Challenges

- Outsider Syndrome
- No Disturbances in Operating Facilities
- Changes Over Time

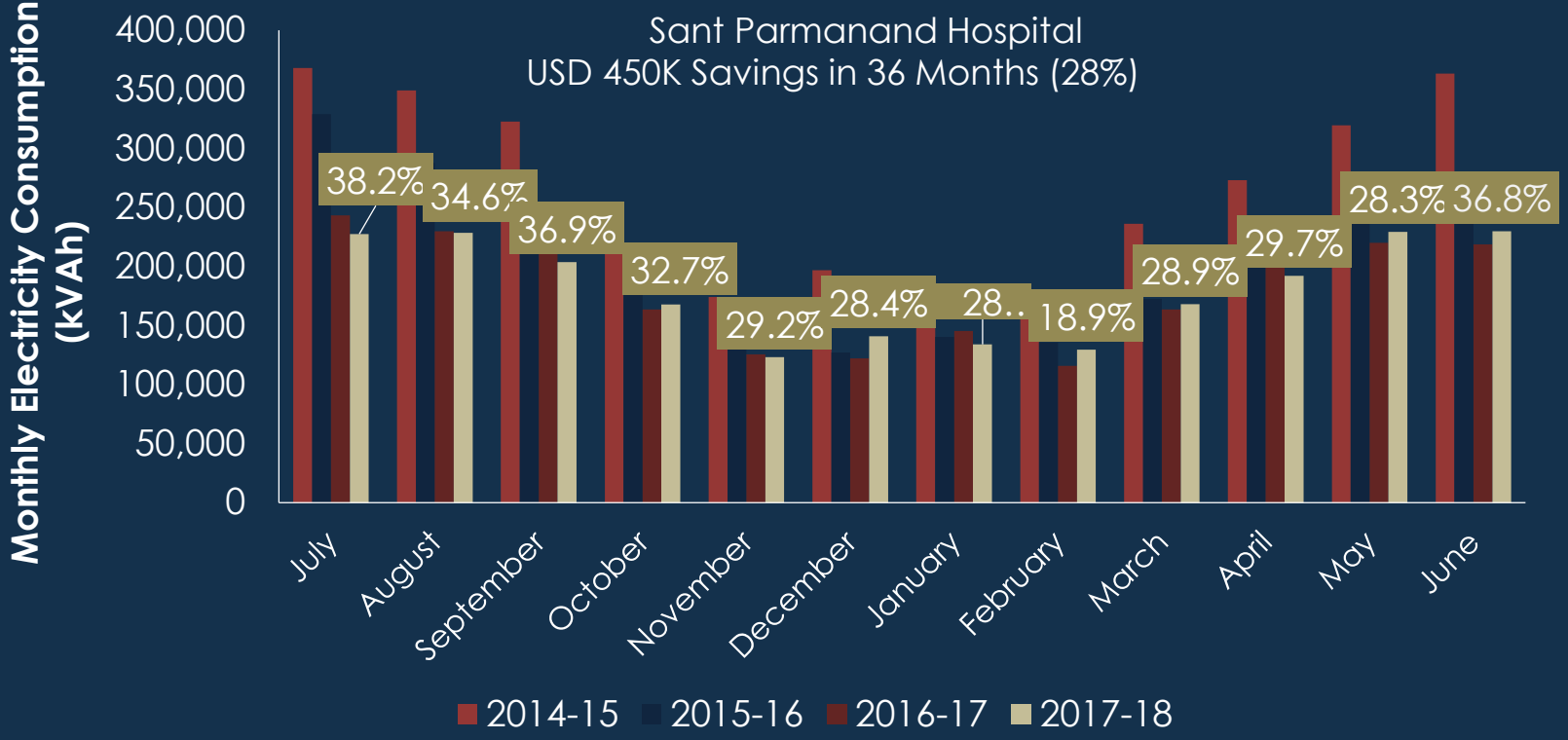



# Learnings

- Outsider Syndrome → Technology and Training
- No Disturbances in Operating Facilities → Technology
- Changes Over Time → Technology

# Multiple benefits of energy efficiency

# Results


Sant Parmanand Hospital
USD 450K Savings in 36 Months (28%)
Monthly Electricity Consumption (kVAh)
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
38.2%
34.6%
36.9%
32.7%
29.2%
28.4%
28..
18.9%
28.9%
29.7%
28.3%
36.8%
July
August
September
October
November
December
January
February
March
April
May
June
2014-15
2015-16
2016-17
2017-18

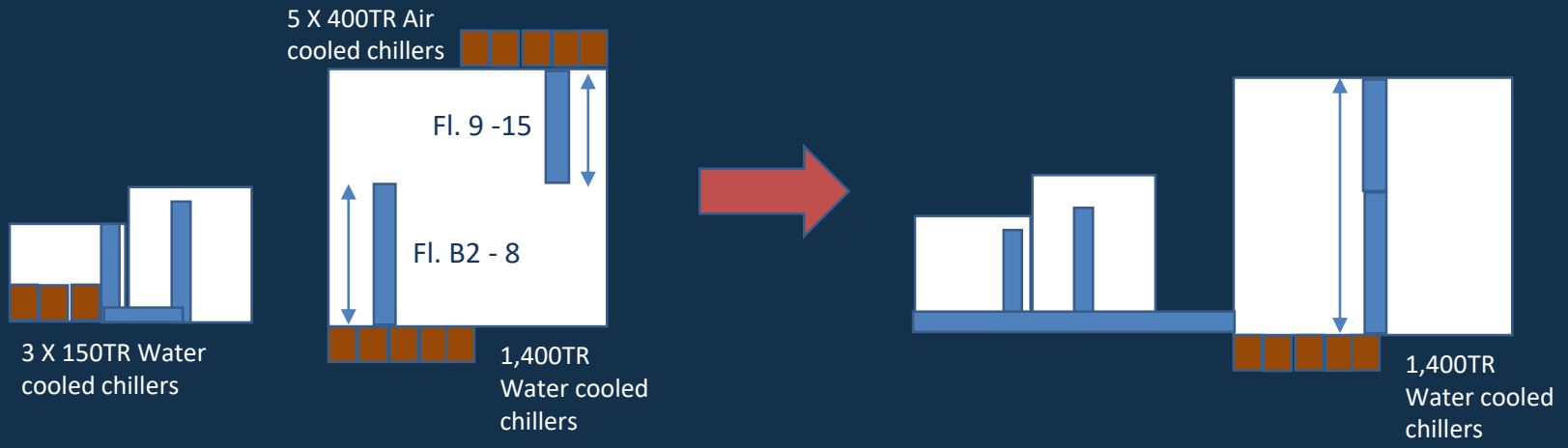
# Results

| Facility Name | Annual Energy Expenditure (INR Lakh) | Average Energy Savings Delivered (%) |
|---|---|---|
| Sant Parmanand, Delhi | 317 | 30% |
| St. Stephens, Delhi | 640 | 24% |
| CMC Hospital, Ludhiana | 714 | 22% |
| Shanti Mukand, Delhi | 190 | 13% |
| Maharishi Ayureda, Delhi | 34 | 23% |
| Mahatma Gandhi Cancer Hospital, Vizag | 200 | 37% |
| SPMM Hospital, Salem | 100 | 21% |
| KIMS Hospital, Hyderabad | 1,300 | 12% (still in execution) |
| G. Kuppuswamy Naidu Memorial, Coimbatore | 1,300 | 72% (still in execution) |
| Fortis Hospital, Noida | 620 | 9% (still in execution) |

# Drivers

- Operational Cost Savings
- Increased Life of Equipment = Capital Cost Savings
- Improved Reliability and Comfort
- Training for Staff
- Culture and Brand Building

# Benefits


5 X 400TR Air cooled chillers
Fl. 9 -15
Fl. B2 - 8
3 X 150TR Water cooled chillers
1,400TR Water cooled chillers
1,400TR Water cooled chillers



KIMS HOSPITALS™

5 Nos. of Air Cooled Chillers of 400 TR each.
Value ~ **USD 350K**

JOULE ₹ PAYS

# Benefits

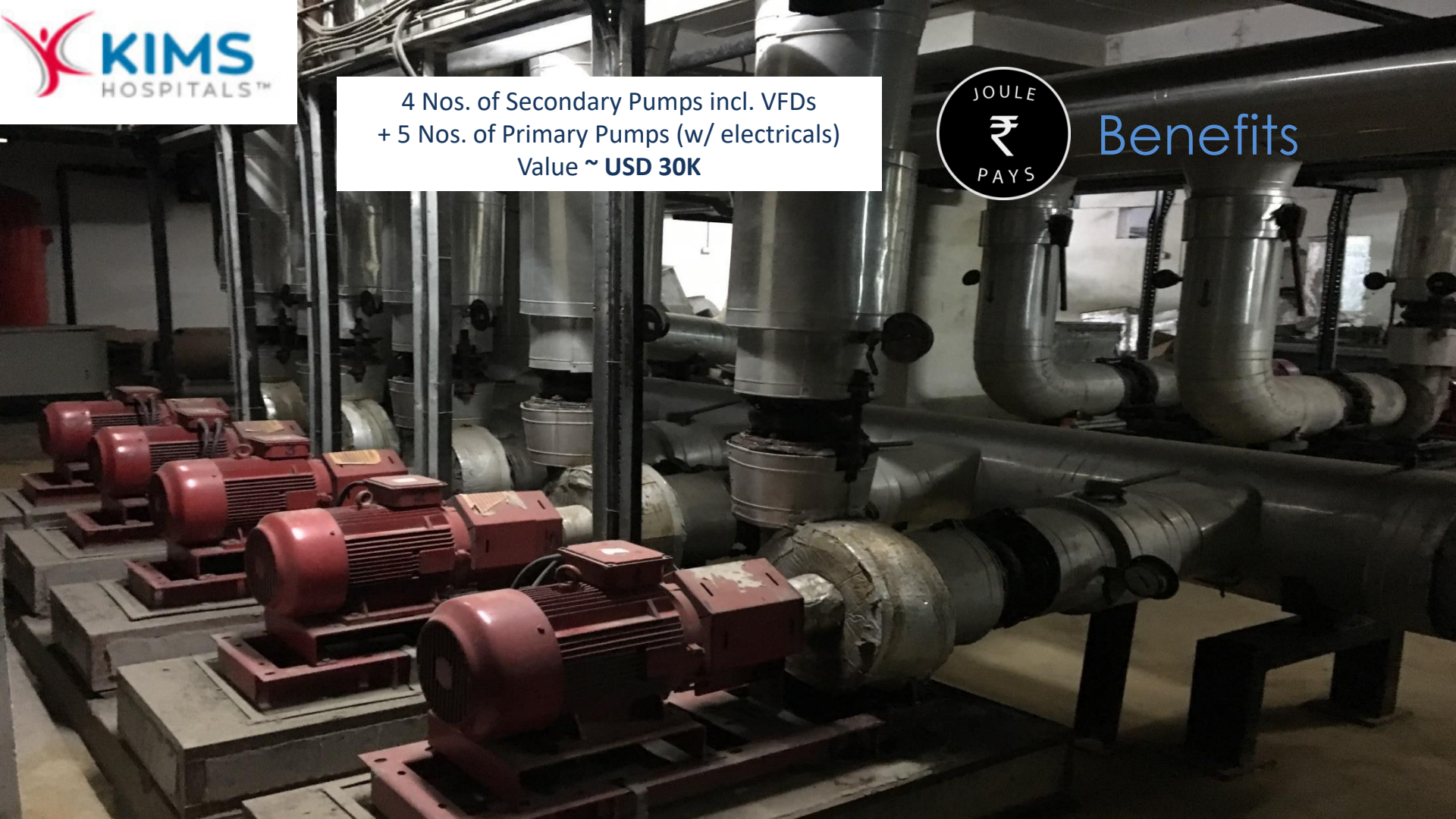


KIMS HOSPITALS™

4 Nos. of Secondary Pumps incl. VFDs
+ 5 Nos. of Primary Pumps (w/ electricals)
Value ~ **USD 30K**

JOULE ₹ PAYS

# Benefits



KIMS HOSPITALS™

**2,000 sq. feet free area**

JOULE ₹ PAYS

# Benefits



# Benefits

Temperature & Humidity Logger

## Rooms

MRI Room

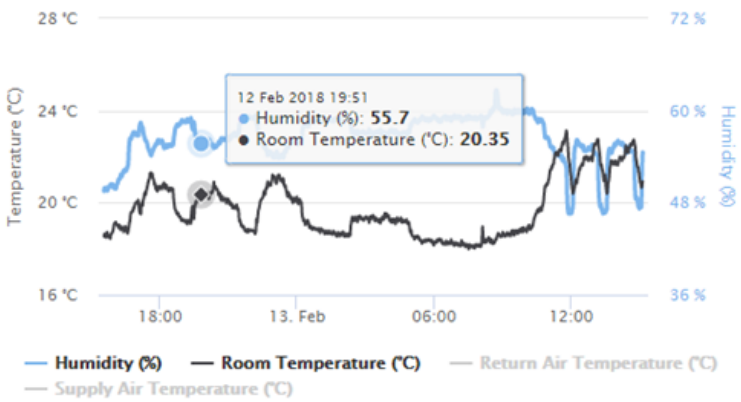
## Live Reading

21.4°C 55.6%

12.8°C 20.8°C

## Historical Data

Last Hour | Last Day | Custom



# Benefits

**Health and Wellness**

- Air changes per hour
- HEPA filter cleaning
- AHU regular filter cleaning

JOULE ₹ PAYS

Benefits

# राष्ट्रीय ऊर्जा संरक्षण पुरस्कार

ऊर्जा संरक्षण हेतु किए गए
प्रशंसनीय कार्य
जो कि अस्पताल क्षेत्र
में प्राप्त की गई उपलब्धियों से सम्बन्धित है
वर्ष 2016 के लिए
भारत सरकार, विद्युत मंत्रालय द्वारा
**मेसर्स संत परमानंद अस्पताल**
सिविल लाइंस (नई दिल्ली) को
प्रथम पुरस्कार से
सम्मानित किया जाता है।

विद्युत मंत्रालय
नई दिल्ली
14 दिसम्बर, 2016

सचिव,
भारत सरकार

# 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*
***M/s Sant Parmanand Hospital***
*Civil Lines (New Delhi)*

*Ministry of Power*
*New Delhi*
*14 December, 2016*

*Secretary to the*
*Government of India*

JOULE ₹ PAYS

# Benefits



# 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 / $m^2$ / 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
- $CO_{2e}$ emissions avoided

Data Easily Available

# Indicators Used



# Other Indictors

**For a Specific Hospital**

- ***Lighting***: Artificial Lighting Intensity, Prevalent Lux levels
- ***Cooling***: $m^2$/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

| Information / Documentation Needed from GKNMH | | |
|---|---|---|
| S.no. | Data required | Remarks |
| 1 | Drawings | |
| 1.1 | Floor Plan (AutoCAD, PDF and hard copies) | To identify use areas and prepare intervention plans. |
| 1.2 | Ducting Layout (AutoCAD, PDF and hard copies) | To identify the served areas from AHUs. |
| 1.3 | Chilled and Cooling Water Piping Layout (AutoCAD, PDF and hard copies) | To identify existing piping routes, pipe sizes, and plan new routes as needed. |
| 1.4 | Electrical Single Line Diagram (AutoCAD, PDF and hard copy) | To understand load distribution, and plan for smart metering. |
| 1.5 | VAM Plant Room Layout(s) (AutoCAD, PDF and hard copy) | To plan interventions |
| 1.6 | Any Other AC Drawings available | To plan interventions |
| | | |
| 2 | Assets list | For Exhibit B and other purposes, as mentioned |
| 2.1 | Bio-medical Equipments (with kW ratings) | To be included in Exhibit B |
| 2.2 | AHUs, FCUs,TFAs with Design details (CFM, kW, TR) and location | To plan interventions in the HVAC system |
| 2.3 | Split/Window/Ductable/Other Unitary ACs (preferably location-wise, if available) | To plan interventions in the AC system |
| 2.4 | Indoor and Outdoor Lights, Ceiling Fans and Exhaust Fans (preferably location-wise, if available) | To plan Lighting and Fan retrofits, as appliable |
| 2.5 | Raw Water Pumps | To plan pumping retrofits |
| 2.6 | Laundry Equipment | To plan steam system retrofits, as appliable |

| Information / Documentation Needed from GKNMH | | |
|---|---|---|
| S.no. | Data required | Remarks |
| 2.7 | CSSD Equipment (sterilizers and boilers) | To plan steam system retrofits, as appliable |
| 2.8 | Kitchen Equipment (boilers, burners, deep freezers, etc.) | To plan kitchen retrofits, as appliable |
| | | |
| 3 | Reports | |
| 3.1 | Previous Energy Audit Reports (TERI and others) | To get a head start in prioritizing interventions |
| 3.2 | Water Quality Testing Reports (Raw Water, treated STP water and Cooling Tower Water) | To plan interventions in the HVAC system |
| 3.3 | Internal Engineering and Maintenance Monthly Reports for Last 12 months | These will have a lot of the data we will need to design our interventions |
| | | |
| 4 | Equipment Design Documents / Brochures | |
| 4.1 | VAM Chillers | To assess sizing, design efficiencies, find best operating points, and interface with software |
| 4.2 | Pumps | |
| 4.3 | Boilers | |
| 4.4 | VFDs | |
| 4.5 | BMS | |
| 4.6 | CSSD Sterilizers and Boilers | |
| | | |
| 5 | Engineering Records (preferably Excel files with 12 months of data) | |

| Information / Documentation Needed from GKNMH | | |
|---|---|---|
| 5 | Engineering Records (preferably Excel files with 12 months of data) | |
| 5.1 | Energy Metering Logs | To find inefficiencies and problem areas that can be addressed as part of the efficiency retrofit |
| 5.2 | Chiller Plant Logs | |
| 5.3 | Temperature Logs | |
| 5.4 | Complaint Logs | |
| | | |
| 6 | Adjustments | |
| 6.1 | New equipment added since Jan. 2017 | |
| 6.2 | Equipment removed since Jan. 2017 | |
| 6.3 | Note on change in use of any area in the Hospital since Jan. 2017 | |
| 6.4 | List of areas within facility that are billed separately for their energy consumption | |
| | | |
| | | |

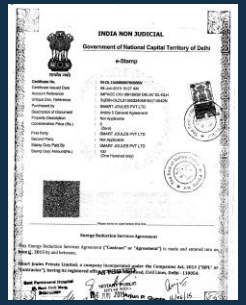
# Indictors

**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

JOULE ₹ PAYS










**Day 0**

Sign **JoulePAYS** Agreement

**<9 months**

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

**5-7 years**

**Continuous Energy Management** by Smart Joules

**End of Term**

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.

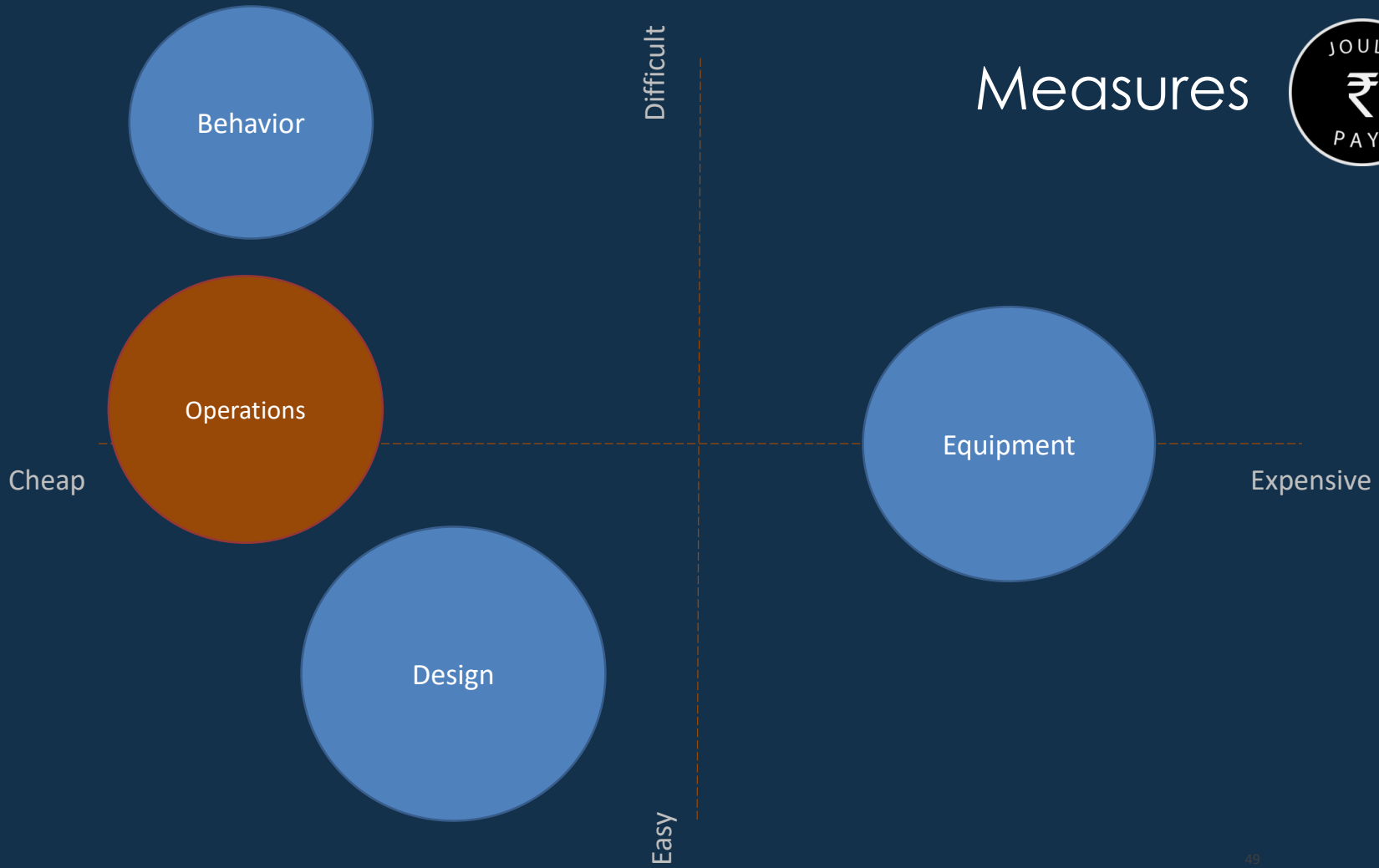
2. **Customer Obligations**

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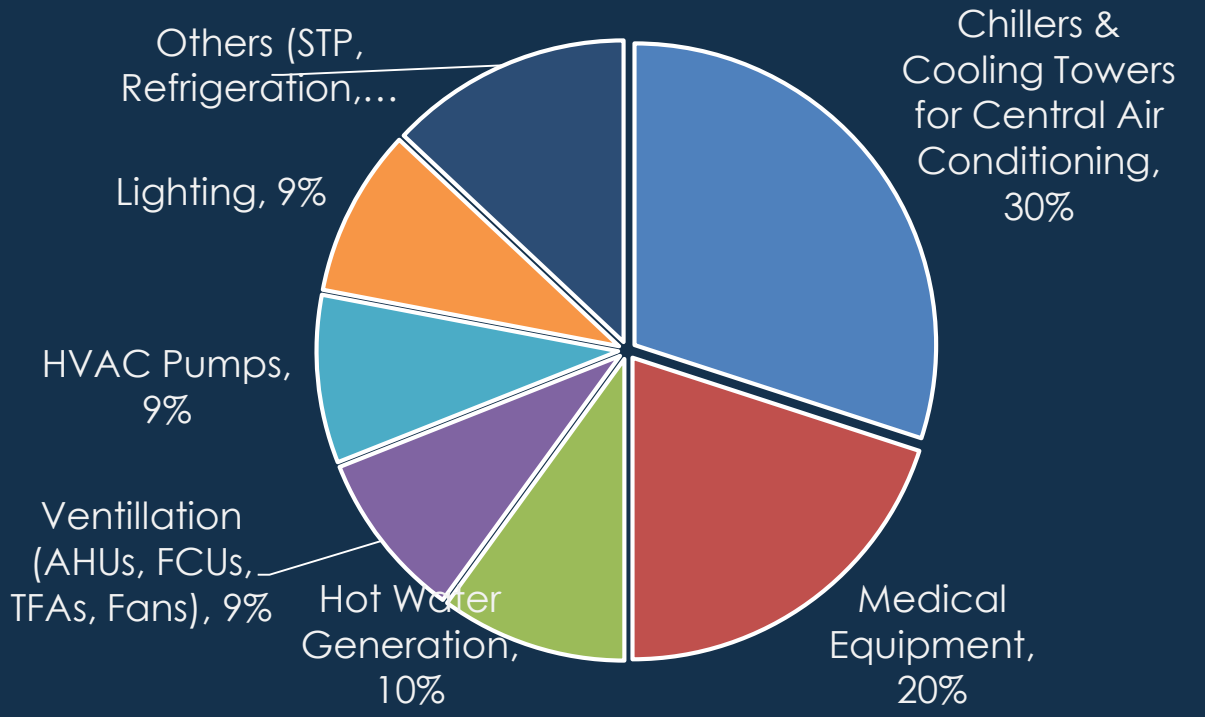
10. **Contractor's Assurance**

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.

# Measures


Behavior
Operations
Design
Equipment
Difficult
Easy
Cheap
Expensive

# Where Do Hospitals Consume Energy?



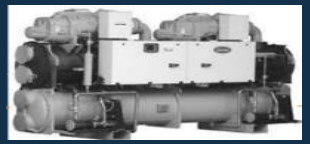
# Measures



Continuous Oversight and Active Management



Energy Manager + Staff Training









Cooling & Heating Optimization



LED Lighting



VFDs



BLDC Fans



IE3/EC Motors



Automation

# Measures

| S.No. | Energy Conservation Measure |
|---|---|
| 1 | ***Chillers*** |
| a | Load Consolidation |
| b | New Chiller(s) |
| c | Run hour optimization |
| d | Chilled water set point optimization |
| e | Chiller sequencing |
| f | Descaling |
| g | Reducing Condenser Approach with ATCS |
| h | Reducing Condenser Approach with Water Quality Improvement |
| i | Evaporative Cooling Pads for Air Cooled Chillers |
| j | DeJoule |
| 2 | ***HVAC Pumps*** |
| a | New Pumps - Chilled Water |
| b | New Pumps - Condenser Water |
| c | Optimizing Chilled Water Flow - Dynamic with VFDs |
| d | Optimizing Chilled Water Flow - One time |
| e | Optimizing Condenser Water Flow - Dynamic with VFDs |
| f | Optimizing Condenser Water Flow - One time |
| g | Run hour optimization |
| h | DeJoule |

# Measures

| S.No. | Energy Conservation Measure |
|---|---|
| 3 | ***Cooling Towers*** |
| a | New Cooling Tower |
| b | Fill Replacement |
| c | Nozzle Cleaning |
| d | Motor Replacement |
| e | VFD Installation |
| f | Run hour optimization |
| g | DeJoule |
| 4 | ***Low Side Optimization*** |
| a | Water Flow Balancing |
| b | Air Flow Balancing |
| c | VFDs for Air Flow Optimization |
| d | Valves for Water Flow Optimization |
| e | Run-hour Optimization |
| f | Set Point Rationalization |
| g | Damper Controls for Different Areas Fed by Same AHU |
| h | Motor Replacement |
| i | Removal of Heating Coils |
| j | Pulley Size Optimization |
| k | Fresh Air % Optimization |

# Measures

| S.No. | Energy Conservation Measure |
|---|---|
| l | Heat Recovery Wheels |
| m | PHE for Recovery of Exhaust Cooling |
| n | Descaling Cooling Coils |
| o | Changing to EC Fans |
| p | DeJoule |
| 5 | ***Heat Load Reduction*** |
| a | Cool Roof Paint |
| b | Films on Windows |
| c | Plugging Air Leakages from End-Use Areas |
| d | Eliminating Mixing of Supply Air with Other Air Streams |
| e | Insulation of Ducts, Pipelines and Other Areas |
| f | Shading of Outdoor AC Units |
| g | Using Door Closers to Prevent Hot Air Entering / Cool Air Escaping |
| h | Using Air Curtains to Prevent Hot Air Entering / Cool Air Escaping |
| 6 | ***Consolidating Cooling Load*** |
| a | Aux. Air Cooled Chiller |
| b | Split and Window ACs |
| 7 | ***LED Lighting*** |
| 8 | ***BLDC Fans*** |
| 9 | ***UPS Load Consolidation*** |

# Measures

| S.No. | Energy Conservation Measure |
|---|---|
| 9 | ***UPS Load Consolidation*** |
| 10 | ***DeJoule*** |
| a | Energy Meter Data Analytics |
| B | Chiller Plant TR Delivery Tracking |
| C | Other Optimization Possibilities |
| 11 | ***Raw Water Pumps*** |
| a | Install Higher Efficiency Pumps |
| b | Control Running of Pumps with Automation |
| 12 | ***Automation*** |
| a | Timers |
| b | Temperature Controllers |
| c | Occupancy Sensors |
| d | Door Switch |
| e | Photo sensors |
| f | Others |
| 13 | ***Laundry*** |
| a | Switching to Electric Boiler |
| b | Optimizing Feed Water Tank Temperature |

# Measures

| S.No. | Energy Conservation Measure |
|---|---|
| c | Improvements in Insulation |
| d | Steam Trap Health Improvement |
| e | Laundry Load Consolidation |
| 14 | ***Kitchen*** |
| a | Proper Cleaning of Burners |
| b | Replacement with Agnisumukh Burners |
| 15 | ***Domestic Hot Water*** |
| a | Boiler Replacement |
| b | Heat Pump Installation to Replace Boiler / Geysers / Elec. Heating |
| c | Tank Size Optimization |
| d | Solar Hot Water System |
| e | Collection and Utilization of Condensate / Waste Hot Water |
| f | Run Hour Optimization |
| g | Set Point Rationalization |
| 16 | ***Power Factor Improvement*** |
| a | Capcitor Panel Installation at LT Panel |
| b | Capacitor Installation at Load-level |
| 17 | ***Space Heating Optimization*** |
| a | Using Heat Pump for Hot Water Generation (Centralized Systems) |
| b | Higher Efficiency Unitary Heaters |

# Measures

| S.No. | Energy Conservation Measure |
|---|---|
| c | Low Speed Fans for Better Heating Distribution |
| 18 | ***CSSD*** |
| a | Use Dedicated Electric Boiler Instead of Centralized |
| b | Increase Boiler Feed Water Temperature |
| 19 | ***Gas Manifold / Compressors*** |
| 20 | ***Biomedical Equipment*** |
| 21 | ***STPs*** |
| a | Blower Replacement |
| b | Pump Replacement |
| c | VFD |
| d | Reducing Amount of Wastewater |
| 22 | ***Exhaust Fans*** |
| a | Temperature Controllers |
| 23 | ***Other Operational Efficiency Improvements*** |
| a | Transformer Load Consolidation |
| b | Remove / Consolidate Stabilizers |
| c | Arrest Ghost Loads |




खतरा
440 VOLT






A1

| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | |
| 2 | | Pump ref | Units | CP1 | CP2 | CP3 | CP4 | CP5 |
| 3 | | Flow | m3/hr | 85 | 127 | 140 | 136 | 130 |
| 4 | | DP | kg/cm2 | 2.4 | 2.4 | 2.4 | 2.4 | 2.6 |
| 5 | | SP | kg/cm2 | 0.6 | 0.2 | 0.2 | 0.2 | 0.2 |
| 6 | | Power | kW | 11.02 | 17.93 | 17.66 | 18.26 | 17.28 |
| 7 | | Efficiency | % | 38% | 42% | 48% | 45% | 49% |
| 8 | Baseline | SEC | kWh/m3 | 0.13 | 0.14 | 0.13 | 0.13 | 0.13 |
| 9 | | Operation Hrs | hrs | 0.00 | 16.50 | 16.50 | 16.50 | 16.50 |
| 10 | | Annual days | days | | 274.17 | 274.17 | 274.17 | 274.17 |
| 11 | | Annual Con. | kWh | | 81,111 | 79,889 | 82,604 | 78,170 |
| 12 | | | kWh | | 321,774 | | | |
| 13 | | Energy Cost | Rs | | 2,574,195 | | | |
| 14 | | | | | | | | |
| 15 | | Flow | m3/hr | | 340 | 340 | | |
| 16 | | Head | m | | 24 | 24 | | |
| 17 | | Power | kW | | 25.9 | 25.9 | | |
| 18 | | Efficiency | % | | 86% | 86% | | |
| 19 | | SEC | kWh/m3 | | 0.076 | 0.076 | | |
| 20 | Armstrong | Operation Hrs | hrs | | **18** | **18** | | |
| 21 | Proposed | Annual days | days | | **274** | **274** | | |
| 22 | 2pumps | Annual Con. | kWh | | 127,598 | 127,598 | | |
| 23 | | | kWh | | 255,197 | | | |
| 24 | | Energy Cost | Rs | | 2,041,575 | | | |
| 25 | | Pump cost | | | 398,945 | 398,945 | | |
| 26 | | with Tax and I&C | | | 455,755 | 455,755 | | |
| 27 | | Total Cost | | | 911,510 | | | |
| 28 | | | | | | | | |
| 29 | | Savings | Rs | | 532,620 | | | |
| 30 | Savings | Payback | years | | 1.71 | | | |
| 31 | | 5 yr Savings | Rs | | 1,751,589 | | | |
| 32 | | | | | | | | |

Analysis | Part load Comparision

# Krishna Institute of Medical Science, Secunderabad

## ECM Note for HVAC Condenser Pumps

MAY 18, 2018

### 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/TR) 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 (GPM)*Delta pressure in meters of WC/360/ Power Consumption*100%



Figure 1: HVAC Pump Performance Measurement



The table below present results of our performance audit:

| Parameters | Unit | Design | Measured | | | | |
|---|---|---|---|---|---|---|---|
| | | | Pump 1 | Pump 2 | Pump 3 | Pump 4 | Pump 5 |
| Flow | m3/hr | 170 | 85 | 127 | 140 | 136 | 130 |
| Head | m | 24 | 18 | 22 | 22 | 22 | 24 |
| Hydraulic Power Output | kW | | 9.5 | 15.4 | 15.2 | 15.7 | 14.9 |
| Power Consumption | kW | 18.5 | 11.02 | 17.93 | 17.66 | 18.26 | 17.28 |
| Power Factor | PF | | 0.83 | 0.84 | 0.84 | 0.84 | 0.84 |
| Overall Efficiency | % | | 38% | 42% | 48% | 45% | 49% |

Table 1: Performance of Condenser Pumps

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:

| Parameters | Condenser Water Pumps |
|---|---|
| Make | Armstrong |
| Quantity | 2 |
| Flow (gpm) | 1,500 |
| Head (m) | 24 |
| Power Consumption at Design (KW) | 25.6 |
| Motor Rating (kW) | 30 |
| Speed (rpm) | 1,401 |
| Frequency (Hz) | 47 |
| Efficiency (%) | 86.95 |

Table 2: Design Parameters of Proposed Condenser Pumps

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CIN.: U40300DL2014PTC273904
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## 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 on-board 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 pitting-related issues that are common in other types of impellers. They have high-quality cast-iron casing, which reduces frictional losses. They also have sintered silicon carbide 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, given our selection of the chillers and other site conditions. 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:

| Scenario | Operating Conditions | Flow (GPM) | Head (m) | Freq. (Hz) | Power (kW) | Efficiency (%) |
|---|---|---|---|---|---|---|
| Standard | When two chillers are operated, two new condenser pumps will be operated in lower frequency. | 1153*2 | 18.1 | 39.3 | 15.1*2 | 85.80% |
| Maximum Load | When three chillers are operated, two new condenser pumps will be operated at high frequency. | 1500*2 | 24 | 47 | 25.6*2 | 86.95% |
| Minimum Load | When one chiller is operated, one new condenser pump will be operated in lower frequency. | 1153 | 18.1 | 39.3 | 15.1 | 85.80% |

Table 3: Operation logic of Condenser Pump

Performance curves of the selected pumps are provided herein below:

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## 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 CapEx since 2-3 of the existing condenser pumps that are replaced could be moved to other sites;
- Reduced maintenance and repair costs.

## SJPL 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 exiting 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.



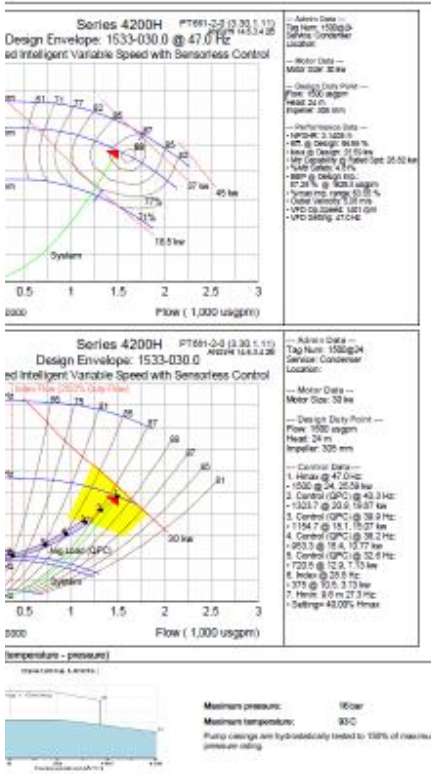



*Figure 3: Performance Curve of Condenser Water Pumps*



## 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. U. V. Sivaprasad

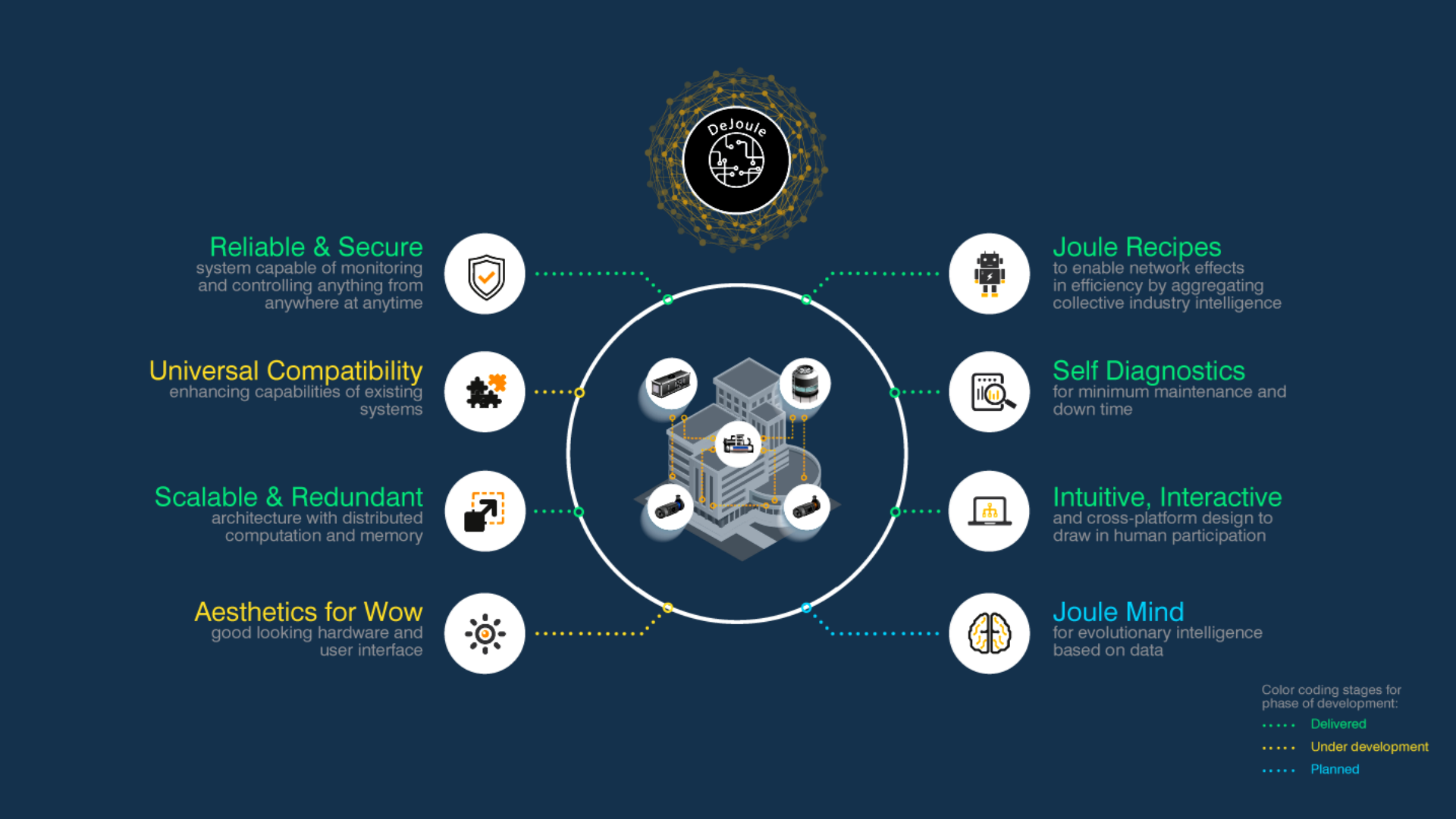
Designation: DGM, Engineering Maintenance

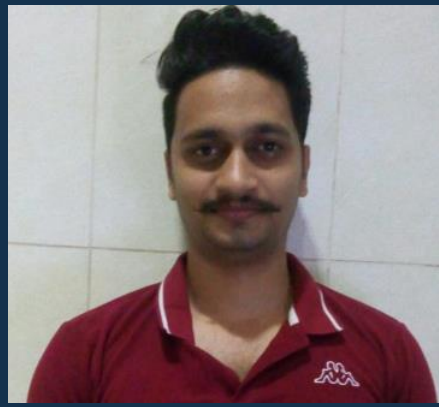
Krishna Institute of Medical Science
No. 1-8-31/1, Minister Road,
Krishna Nagar Colony, Begumpet,
Secunderabad,
Telangana 500003


NO SMOKING






DeJoule
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



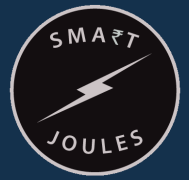
## Efficient Operational Procedures

### 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**

| Sr. No. | AHUs location | Airflow (CFM) | Rated KW | Current Operating frequency | Day time avg. temp. | Remarks |
|---|---|---|---|---|---|---|
| 1 | OT-1 | 3000 CFM | 3.7 | 50 Hz for whole day | 19.5 | |
| 2 | OT-2 | 4000 CFM | 3.7 | 50 Hz for whole day | 19.4 | |
| 3 | OT-3 | 3000 CFM | 3.7 | Un-commissioned | 17.7 | SJPL planning to commission the un-commissioned VFDs |
| 4 | OT-4 | 3000 CFM | 3.7 | Un-commissioned | 18.6 | SJPL planning to commission the un- |




Term Loan




Loan Guarantee




Partial Risk Sharing Facility






## 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




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