Implementation of energy efficient technologies/measures in existing buildings

Gaps and Barriers

- Energy Audit Methodology
- Retrofit guidelines
- Energy rating systems
- No format/layout
- Parameters
- Frequency of data collection
- Measurement and Verification protocol
- Financial Mechanism
- Energy Audit Methodology
- Tools/techniques
Energy Survey

Collection of design data
Collection of operating data using BMS/log books
Building energy systems/HVAC plant monitoring using appropriate instruments

Comfort monitoring

Visual Comfort

<table>
<thead>
<tr>
<th>Spaces</th>
<th>Operating levels</th>
<th>NBC Recommended levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office (cabins)</td>
<td>510</td>
<td>300-500-750</td>
</tr>
<tr>
<td>Toilets</td>
<td>170</td>
<td>100-150-200</td>
</tr>
<tr>
<td>Cafeteria</td>
<td>230</td>
<td>150-200-300</td>
</tr>
<tr>
<td>Circulation areas</td>
<td>125</td>
<td>50-100-150</td>
</tr>
<tr>
<td>Meeting rooms</td>
<td>515</td>
<td>300-500-750</td>
</tr>
</tbody>
</table>

Thermal Comfort
Data collection

Baseline Development

Baseline Development

Thermal and Visual Comfort

Design and operating performance of equipment

Energy consumption profiles
Energy Conservation Measures

Building Envelope
- Cool roof
- Paints
- Roof insulation
- Film on glass

Lighting
- Visual comfort
- Lighting controls
- Efficient lamps and fixtures

Air conditioning
- Efficient design
- Set point temperature
- Optimization
- Efficient equipment
- Energy Recovery
- Radiant/Geothermal

Automation
- Demand based control
- All variable chiller plant

Implementation

Measurement and Verification Protocol

Baseline Development

Monitoring & Instrumentation

Implementation Schedule

Retrofitting

Post retrofit monitoring

Baseline adjustment

Verification of energy savings

Baseline Development
Baseline development and adjustment - Weather dependent system

<table>
<thead>
<tr>
<th>CDW in (deg F)</th>
<th>100</th>
<th>90</th>
<th>80</th>
<th>70</th>
<th>60</th>
<th>50</th>
<th>40</th>
<th>30</th>
<th>20</th>
<th>15</th>
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</thead>
<tbody>
<tr>
<td>70</td>
<td>0.426</td>
<td>0.404</td>
<td>0.388</td>
<td>0.378</td>
<td>0.374</td>
<td>0.382</td>
<td>0.4</td>
<td>0.441</td>
<td>0.5</td>
<td>0.576</td>
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<tr>
<td>75</td>
<td>0.472</td>
<td>0.451</td>
<td>0.438</td>
<td>0.43</td>
<td>0.433</td>
<td>0.44</td>
<td>0.464</td>
<td>0.496</td>
<td>0.578</td>
<td>0.658</td>
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<tr>
<td>80</td>
<td>0.52</td>
<td>0.502</td>
<td>0.492</td>
<td>0.49</td>
<td>0.496</td>
<td>0.507</td>
<td>0.525</td>
<td>0.57</td>
<td>0.661</td>
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<tr>
<td>85</td>
<td>0.576</td>
<td>0.562</td>
<td>0.549</td>
<td>0.552</td>
<td>0.554</td>
<td>0.576</td>
<td>0.597</td>
<td>0.648</td>
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<tr>
<td>89</td>
<td>0.624</td>
<td>0.609</td>
<td>0.604</td>
<td>0.605</td>
<td>0.613</td>
<td>0.627</td>
<td>0.653</td>
<td>0.707</td>
<td>0.817</td>
<td>0.924</td>
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</tbody>
</table>

Financial Mechanisms

Client → ESCOs → Energy efficiency services limited (EESL) → Third party evaluator for energy savings
Case Study
Space cooling and heating systems in India

<table>
<thead>
<tr>
<th>Space cooling</th>
<th>Off grid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window AC</td>
<td>Wood burning</td>
</tr>
<tr>
<td>Split AC</td>
<td></td>
</tr>
<tr>
<td>Central plant</td>
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</tbody>
</table>

On grid

<table>
<thead>
<tr>
<th>Space heating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical oil type heaters</td>
</tr>
</tbody>
</table>

Off grid

<table>
<thead>
<tr>
<th>Space heating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

Environmental Issues in off-grid regions

- Burning of twigs for heating
- Deforestation
- Air Pollution (formation of carbon layer in atmosphere)
Technology option

Space cooling

Heat Pump (both space Heating & Cooling)

Space heating

Technological options for heat pump

- Air source heat pump
- Water source heat pump
- Geo-source heat pump

![Full load COP (Cooling)](chart1)

- Full load COP (Cooling)
- Full load COP (Heating)

- Oil type radiative heater
- Air source heat pump (VRV)
- Water source heat pump (VRV)
- Water (Geo) source heat pump (VRV)

Full load COP or Seasonal part load value (SPLV)
Proposed System (on grid and off-grid)

Case Study - Installation of Geothermal based heat pump at Science Centre, Itanagar
Site for Geothermal based Heat Pump Installation

Science Center, Arunachal Pradesh

Cooling and heating requirement

- Cooling load: 5 TR
- Heating load: 7 TR
**Geothermal Slinky Design Parameters**

- **Length of Trench**: 500 ft (1000 ft per loop)
- **Depth of Trench**: 7.5 ft
- **No. of Slinky Loops**: 5
- **Pipe Thickness**: 2-2.5 mm
- **HDPE pipe**: 32 mm

**Heat Pump Specifications - Water (Geo) source Variable Refrigerant Flow**

- **Make**: Samsung
- **Type**: DVM S WATER
- **Model Name**: AM080FXWANR/EU
- **Power Supply**: 3,4,380-415,50/60 Hz
- **Mode**: HEAT RECOVERY

<table>
<thead>
<tr>
<th>Performance</th>
<th>HP</th>
<th>HP</th>
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</thead>
<tbody>
<tr>
<td>Capacity (Nominal)</td>
<td>Heating</td>
<td>TR</td>
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<tr>
<td>Power Input</td>
<td>Cooling 1</td>
<td>kW</td>
</tr>
<tr>
<td>Current Input (Nominal)</td>
<td>Heating 2</td>
<td>A</td>
</tr>
<tr>
<td>Power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency</td>
<td>TR</td>
<td></td>
</tr>
<tr>
<td>Nominal Cooling 1)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Nominal Heating 2)</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

| Compressor | Type | - | SSC Scroll x 1 |
| Condenser | Type | - | PHE (Plate Heat Exchanger) |
| Water Flow Rate | USGPM | 20.0 |
| Max. Pressure | MPa | 1.96 |
| Refrigerant | Type | - | R410A |
| Control | - | EEV - Electronic Expansion Valve |

| External Dimension | Net Weight | kg | 100.0 |
| Net Dimensions (WxHxD) | mm | 770 x 1,000 x 545 |
| Operating Temp. Range | Cooling | °C | 10.0 - 45.0 |
| | Heating | °C | 10.0 - 45.0 |
System Comparison with Conventional Heat Pump (Energy Simulation Results)

Cooling mode
Energy consumption with conventional heat pump : 5486 kWh/yr
Energy consumption with geothermal heat pump : 3924 kWh/yr
% Saving : 29%

Heating mode
Energy consumption with conventional heat pump : 2004 kWh/yr
Energy consumption with geothermal heat pump : 1382 kWh/yr
% Saving : 31%

Digging of trench for geo-exchange

Digging through JCB machine

Digging through manual labour
Preparation of slinky loops
Slinky were prepared manually with the help of a die

Laying of slinky in the trench
Refilling of the trench

After setting the slinky ends, the trench was refilled and levelled with JCB machine.

Connection of slinky ends to inlet/outlet manifolds with appropriate fittings

Pipe ends were connected to the inlet and outlet manifolds through compression fittings.
Testing of Geo-exchange System

The testing results at a flow rate of 4.1 USGPM for one of the slinky

The average heat rejection per slinky was calculated to be around 1 TR.

Commissioning of Indoor Units (IDUs) with Refrigerant and Drain Piping

4 No's Indoor Units of 1.6 TR capacity each were installed in the Auditorium. Leak test of drain pipes; and Vacuum test of refrigerant tubing were also carried out.
Commissioning of Outdoor Unit (ODU)

Installation and Testing of Y-strainer, Flow Switch, Air-Vent valve, Pressure & Temperature gauges, Pressure Tank and Water Circulation Pump with ODU.

Satisfactory operation of all the systems was ensured.

Commissioning of Remote Monitoring System (RMS)

DMS - Data Management Server
Internet Modem
PIM - Power Interface Module
RMS Interface
Radiant floor cooling/heating system

Energy and cost analysis-Radiant cooling

**Geothermal system**

<table>
<thead>
<tr>
<th>Energy savings</th>
<th>30-40%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costing</td>
<td>1.2 Lakh Rs/TR</td>
</tr>
<tr>
<td>Payback</td>
<td>3 years</td>
</tr>
</tbody>
</table>
Geothermal system

- Peak Building Load: 75 TR
- Average Building Load: 40 TR
- Load catered by Geothermal vertical system: 20 TR

Resource and cost analysis - Geothermal

**Geothermal system**

- Energy savings: 10-15%
- Water savings: 14L/TR
- Costing: 40000 Rs/TR
thank you