Gas engine energy flow

100% Energy

Energy wasted

7% - Coolant loss
11% - Stack loss

2% - Radiative heat

18% - Jacket Heat
22% - Exhaust gas heat

42% - Electrical output

Utilised energy
Trigeneration technology

Trigeneration involves the simultaneous production of electricity, space cooling/heating using absorption chillers in summer and hot water.
**Benefits of trigeneration**

- Efficiency of engine increases up to 80% from 40%
- Base load electrical and cooling supply
- Reduction in contract demand and peak demand
- Reduced primary energy cost
- Reduced energy consumption and CO2 emissions
- Minimum NOx and SOx
Feasibility analysis of trigeneration

Availability of gas (Natural gas, Bio gas, producer gas)

Requirement of power, cooling and hot water

Policies and programs
Performance of trigeneration

**Electrical output**
- kW/SM3: 4-4.2

**Cooling produced**
- TR/SM3: 1.3-1.35

**Overall energy performance**
- kWh/sqm/yr: 150

**Cost benefit analysis**
- INR/KW: 50000

*The payback period is around 2-3 years*
Applications of trigeneration technology-building sector

In addition to hotels, hospitals, trigeneration could be feasible in SEZs, big campus and smart cities
Status in India

Around 522 MW based on co- and tri-generation has been installed in India.

Potential in India

Building stock in area (m²) will increase by 140% by year 2021 taking year 2011 as base year
Building example for Trigeneration

- Climate: Composite
- Occupancy schedule: 100% for daytime and 50% for rest of the hours
- Total Built up area: 675263 sqft
- Total conditioned area: 530874 sqft
- % conditioned area: 78.7%
### Design engine performance

<table>
<thead>
<tr>
<th>Output</th>
<th>100%</th>
<th>75%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy produced per m³ of gas consumed (kWh/SM³)</td>
<td>4.14</td>
<td>4.05</td>
<td>3.77</td>
</tr>
<tr>
<td>Engine Output (TR/SM³)</td>
<td>1.3</td>
<td>1.36</td>
<td>1.43</td>
</tr>
</tbody>
</table>

*Engine power output decreases at part load and waste heat increases*
### Electrical load analysis

**Hourly variation of total electrical demand (kW)**

- **Max building load during peak period**: 3568 kW
- **Max building load during lean period**: 3019 kW
- **Min building load during peak period**: 2253 kW
- **Min building load during lean period**: 1804 kW
Cooling demand analysis

Hourly electrical demand (kW) of HVAC system

Max cooling load during peak period 1337 kW
Max cooling load during lean period 802 kW
Min cooling load during peak period 937 kW
Min cooling load during lean period 547 kW
## Combined heat and power system

<table>
<thead>
<tr>
<th>Engine</th>
<th>VAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating</td>
<td>1.2</td>
</tr>
<tr>
<td>No</td>
<td>2</td>
</tr>
<tr>
<td>Rating</td>
<td>0.6</td>
</tr>
<tr>
<td>No</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>3.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Screw chiller</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating</td>
</tr>
<tr>
<td>No</td>
</tr>
</tbody>
</table>
% loading of the engine varies from 74% to 96%
## Cooling analysis

<table>
<thead>
<tr>
<th>Month</th>
<th>% VAM</th>
<th>% Screw</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>98</td>
<td>2</td>
</tr>
<tr>
<td>April</td>
<td>87</td>
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<tr>
<td>May</td>
<td>75</td>
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<td>June</td>
<td>60</td>
<td>40</td>
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<tr>
<td>July</td>
<td>56</td>
<td>44</td>
</tr>
<tr>
<td>August</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>Sept</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>October</td>
<td>86</td>
<td>14</td>
</tr>
<tr>
<td>November</td>
<td>90</td>
<td>10</td>
</tr>
</tbody>
</table>

*During lean summer, 90% of cooling is met by VAM and during peak summer, around 60% cooling is met by VAM.*
Gas Consumption

Monthly variation of gas consumption (M3)

48 Lakh SCM of gas offset the 188 lakh kWh/yr in a commercial building
Polices and regulations for trigeneration

Model policies and regulations

- Energy Conservation building code
- Rating systems
- Smart cities program
- Clean energy technology
Identification of possible regions and buildings in India for trigeneration technology

Regions where power supply is intermittent
Optimized electrical load (kW)
Engine size with % loading between 85% to 95%

Regions where gas is available
Optimized cooling demand (TR)
VAM size to offset base cooling load (TR)

Identification of buildings where trigeneration is feasible like hotels, hospitals, airports etc
Optimized hot water requirement (lpd)

Sizing of Gas engine, VAM and electrical chillers

Sizing of electrical chillers

Performance analysis

Gas engine SEC (kW/SCM)
Overall cooling kW/TR
Building EPI

Cost benefit analysis

Initial cost increment due to gas engine and VAM
Initial cost reduction due to size reduction of electrical chillers and hot water generators.

Estimation of tariff and operating cost

Benefits

Estimation in reduction in kWh and monetary benefits
Estimation in reduction of carbon dioxide

Identification and partnership with technology providers

Engine manufacturers
VAM manufacturers
Design consultants

Innovative financing models

EEESL deemed saving model/ESCO models
Low interest loans
Public Private Partnership

Ensuring performance of trigeneration by developing M&V

Gas engine loading and performance
Temperature of waste gases and amount of cooling and hot water produced
Overall energy consumption

Marketing and Outreach

Demonstration projects
Knowledge and awareness programs
Workshops and conferences
Thank you
Building Relationships...

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