Cogeneration and Trigeneration – Tools for Energy Efficiency

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Session: Biz Tech Talk – Industries and Supply Chain: EE Solutions to achieve scale

- Ashish Vaishnav, Thermax Ltd
Agenda

• Concept of Cogeneration and Trigeneration
• Applications and advantages of Cogeneration and Trigeneration
• Issues and Challenges faced in adoption
• Innovative Solutions and Business Models
• Case Studies
• Q & A
CoGeneration and TriGeneration Concept

CoGeneration means Combined Power and Heating or Cooling Generation

TriGeneration is the simultaneous generation of Mechanical/Electrical AND Thermal Energy, Cooling in a Single, Integrated system

Power generating engines vent huge amounts of high temperature exhaust gases into the atmosphere with high levels of heat energy present in it. If connected to a heat recovery system, the waste heat from genset can be effectively utilized to generate Steam/Hot Water. Part of this steam is used to run Chiller
DRIVERS For Cogeneration and Trigeneration

- Gap in Demand Supply of Grid Power
- Inherent Low thermal efficiency of ‘Power Equipments’
- Power Generation Cost of Gensets w.r.t. Grid Power
- Govt. Regulation Favouring Cogen/Trigen
Cogeneration & Tri-generation - Technology and Application Solutions

Gas Engine
- Exhaust Only
- Exhaust + Jacket Water
- Exhaust + Jacket Water + Backup Gas Firing
- Jacket Water recovery

Micro Turbine
- Turbine Exhaust

Gas Turbine
- Exhaust Only
- Exhaust + Backup Gas Firing

Steam Turbine
- Steam Extraction recovery
- Steam backpressure recovery

Heat Recovery
Cogeneration and Trigeneration System Efficiency

Overall System Efficiency without Heat Recovery = 40%

Overall System Efficiency with Heat Recovery = 75 - 80%
Trigeneration WORKING PRINCIPLE

- **FUEL**
- **ENGINE**
  - **POWER**
  - **FLUE GAS**
  - **FLUE GAS INLET**
  - **FLUE GAS OUTLET**
- **DAMPER**
- **ENERGEN**
  - **STEAM**
- **VAM**
  - **COOLING**
- **CHIMNEY**

**BY PASS FLUE GAS PATH**
Trigeneration through Exhaust Chiller – Innovation Solution

- Gas Engine
- 3 Way diverter Damper
- Silencer
- Chimney
- Absorption Chiller
- Engine Exhaust
- Engine Exhaust In
- Engine Exhaust Out
- Chilled Water In
- Chilled Water Out
- Chilled Water In
- Chilled Water Out
- Jacket Hot Water In
- Jacket Hot Water Out
- Cooling Water In
- Cooling Water Out
- Burner
Issues & Challenges faced by Industries ....

• Use of alternative fuels - from FO/Diesel/Coal to Natural gas /Biomass/Bio gas
• Rising costs of Power and Energy bills
• Reducing Carbon Foot print
• Refrigerant issues for electrical compression Cooling supply
• Challenges of fuel supply – biomass, natural gas, bio gas
• Increasing Energy Efficiency
Innovative Solutions and Business Models

Innovative Solutions

• Integration of Thermally activated Cooling technology in existing heating systems – Cogeneration – Heating and Cooling!
• Converting heating only boilers into power + heating Cogeneration
• Conversion to bio fuels – biomass, pellets, bio gas, bio gasification
• Application of Absorption Heat pumps / Chiller heaters / Chillers for Cooling (including low temp) and Heating
• Gas based Cogen and Trigeneration
• Hybrid Cooling and Heating solutions

Business Models

• Outsourcing of Operation and maintenance to avoid creation of new skilled manpower
• Leasing of equipment to avoid CAPEX
• Working with ESCOs to take advantage of “Pay as you Save”
## Applications Across Industry Segments

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Distributed Energy - District cooling Solutions

Energy Efficient and Environmental friendly ESCO Solutions for

• IT Parks
• Commercial clusters
• Hospitals & Hotel
• Airports
• Educational Institutes
Dinanath Mangeshkar Hospital, Pune

- **Engine Make**: MWM (Caterpillar)
- **Engine Capacity**: 1200 kVA x 3 Nos
- **Chiller Capacity**: 350 TR x 2 Nos, 336 TR x 1 No
- **Chiller Model**: EJ 30C THU
- **Application**: Air Conditioning of Hospital

- Saving 5.56 Million units of electricity per annum
- Reducing 5400 tons of CO2 emissions per annum

Equivalent to plant 533,900 Tress & Taking 1000 cars off the road per annum
• The Building consists of total 14 Floors.

• Ground & First Floor – OPD’s, Pharmacy, Blood Bank, Canteen and Diagnosis Areas.

• First to Fourth Floor – NICU, ICU’s Dialysis, Dormitories.
• Fifth Floor – OT’s
• Sixth Floor – Service Floor (AHU’s for OT’s).
• Seventh Floor to 14th Floor – Patients Rooms.
SNAPSHOTS OF OPERATIONAL BMS / DASHBOARD

AHU SUMMARY

COOLING TOWERS

ENGINE AND VAM OPERATIONS

VARIABLE AREA RECORDS
BUILDING AREA - 55,740 Sq.M.
AIRCONDITIONED AREA - 23,225 Sq.M.
NO. OF OCCUPANTS - 3500 Persons.
PEAK CAPACITY IN TR - 1056 TR.
CONNECTED LOAD IN KVA - 1747 KVA
The Project consists of 3 Nos. 1.2 MW Natural Gas Fired Engines. (2w + 1s Added Later).

Each 1.2 MW Engine is connected to 1 No. 352 TR Vapour Absorption Chillers fired on hot gas exhaust and Engine Jacket Hot Water. – Total Capacity 1056 TR (2w + 1s).

Operating Hours Per Annum – 8760 Hrs. (24 x 7).

The entire project has been designed with Primary and Secondary Variable Pumping system installed in the Utility Building.

The total requirement of the project is 1056 TR in Phase 1 + Phase 2. Presently the installation is (2W + 1S) – 2 Nos. VAM as working & 1 No. as Standby Newly Added, earlier we had 2 Nos. 180 TR Water Cooled Screw Chillers as Standby and also as backup augmentation.

The Total installation is 1056 TR, with provision of adding another 1.2 MW engine and another 352 TR VAM Working & Standby, taking the total installation to 1408 TR. All 3 VAM as working & Screw Chillers as Standby and augmentation.
Reasons why a Tri-Generation Plant was opted for.

❖ The cost of bringing the required electrical connection from the nearest sub station was 6.0 Crores in 2010.

❖ Piped Natural Gas was promised by MNGL at the gate without any extra cost by 2014.

❖ The overall cost of generation of electricity at site has worked out to be Rs.7.50 / Per KWH including the cost of Natural Gas, and the cost of electricity available from electricity board is Rs.15/- Per KWH being a Commercial Establishment as per Electricity Board.

❖ Hence it was cheaper to generate the electricity at site using Natural Gas fired Engines, considering the initial cost and the Interest cost on the same.

❖ The total cost of HVAC works was 11.36 Cr. Including cost of VAM, Screw Chillers, Ancillary works. The cost without VAM was 9.76 Cr.

❖ The overall saving in reducing the connected load using a VAM was (352 TR X 0.6 IKW/TR) = 211 KW for each chiller x 2 Nos. = 422 kW

❖ Hence Estimated saving on the running cost of chillers = 422 kW x 15/- KWH x 24 Hrs x 365 day x 0.6 Div. = 3,32,70,480 / Per Year.

❖ The investment done for Engines + VAM + Balance of Plant + Utility Building was Rs.12.0 Cr. Hence additional investment of 6.0 Cr. Compared to the cost of bringing the electricity from nearest sub station.

❖ Hence the Payback on the additional investment was – 6.0 Cr/ 3.32 Cr. = 1.8 Years. Considering only the saving of the energy cost of running screw chillers.
FINANCIAL SAVINGS

❖ The total generation of electricity annually & Saving in Running Cost in INR.
2015 - 85.4 Lakh Units - 4.20 Cr. Saved.
2016 - 84.8 Lakh Units - 8.19 Cr. Saved.
2017 - 86.13 Lakh Units - 7.74 Cr. Saved.
2018 - 44.84 Lakh Units - 5.38 Cr. Saved. Till End October 2018.

❖ The Total Savings of 25.97 Crores is after deduction of Maintenance Cost in 42 Months.

❖ Total Investment on the project was 9.76 Cr + 12 Cr. = 21.76 Cr. Hence the payback on the total investment was achieved in 35 Months with an average saving of 0.62 Cr. Per Month.
GAIL Jubilee Towers, Noida

- **Engine Make**: MWM ( Caterpillar)
- **Engine Capacity**: 774 kW x 2 Nos
- **Chiller Capacity**: 220 TR x 2 Nos
- **Chiller Model**: EJG 30A THU
- **Application**: Air Conditioning of Office Building

- Saving 2.30 Million units of electricity per annum
- Reducing 2200 tons of CO2 emissions per annum
- Equivalent to plant 221,100 trees & Taking 440 cars off the road per annum
Waste to Energy Integrated District Cooling/Heating

Uppsala, Stockholm, Sweden

- Fourth largest city of Sweden
- 95% of the properties are heated using district heating
- Household & industrial waste incineration plant generates steam to drive 2 Heat Pumps
- Heat pump operates as chiller generate 6°C chilled water for district cooling in summer - May through September.
- Heat Pump generates 75°C hot water for district heating in winter - October through April
- Maximum district cooling load = 20MW = 5600 TR
- This waste-to-energy plant is designed to burn about 52 tons of waste per hour
- In winter to take care of additional heating load, peat and woodchips are also used as fuel

Highlight: Chiller in summer, heat pump in winter
Industrial District Energy + Heating and Cooling

Gulf JP, Thailand

EPC: Toyo Engineering, Japan

- Greenfield industrial zones with power and utilities supply
- 8 MW Siemens Gas Turbine SGT 800
- EGB to generate steam
- Steam drives double effect absorption chillers:
  - NNK Site: 800 x 4 = 3200 TR
  - NLL Site: 925 x 5 = 4625 TR
- Chilled water is supplied to nearby industries (e.g. Michelin tyre plant)
Garden's By the Bay, Singapore: Air-conditioning the botanical garden domes

- Two gigantic glass greenhouses just one degree north of the equator in one of the hottest and most humid climates in the world

- 5000 tons of timber clipping a month from the 3 million trees of Singapore is the fuel to run biomass boiler.

- Hot water (110°C) from the boiler drives two absorption chillers, 510 TR each.

- Plant operates are 4°C, 7°C and 10°C chilled water conditions depending upon the time of day.

- Heat from the plant regenerates a liquid desiccant that removes moisture from fresh air supply.

- Green waste combined with ash from biomass is used for fertiliser.
Garden's By the Bay, Singapore: Air-conditioning the botanical garden domes

Sustainability

Courtsey: Wilkinson Eyre, Architects
Thank You!

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