Distributed Generation in Industrial Facilities

15 Nov 2011

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Presentation Outline

- Distributed Generation
- Tri-generation
- Case study
- Conclusion

Distributed Generation

Embedded generators generating electricity primarily for on-site consumption and not to compete with gencos in the electricity market

Applications:

- Combined heat and power
- Emergency/Temporary power
- Price hedging

Tri-gen Installations Supported by NEA

Installations		Electricity Output (kWe)	Thermal Output (kWt)	Cooling Output (kWt)
Mirco-turbine tri-gen system	Design	56	310	582
	Operating	38	122	388
Town gas fired gas engine with burner	Design	655	339 + 556 (from burner)	-
	Operating	570	473	-

Tri-gen Installations Supported by NEA

Installations		Electricity Output (kWe)	Steam Output (MT/h)	Cooling Output (kWt)
Natural gas fired tri-gen plant 1	Design	5,000	12.7	4,500
	Operating	4,600	11.5	4,750
Natural gas fired tri-gen plant 2	Design	10,000	24.1	14,068
	Operating	9,100	24	17,057

Case Study

Proposed Tri-gen System

- Electricity demand about 4MW
- Steam demand average 2.5 t/hr at 8 bar
- Hot water requirement of 350 kW at 60 deg C
- Cooling > 6000kWt

Generator sized to meet hot water demand

Tri-generation System

Primary energy (Input)

	% PE	Power (MW)	Consumption per year (MWh)	NG Cost (S$)	CO2 emission (tonnes)
Natural Gas	100%	4.39	34,600	2,430,000	6,370

Energy Production

Energy (Output)	% PE	Power (MW)	COP/Extra Usage (MW)	Yearly production (MWh)
Electricity	41%	1.8	0.16	*12,900*
Steam	18%	0.8		*6,300*
Chilled water	16%	0.7	0.7	*3,850*
Hot water	8%	0.34		*2,700*
Losses	17%	0.75		*5,950*
	100%	4.39		

Conventional System (separate production)

	Consumption (MWh/year)	Efficiency/COP	Energy (MWh/year)	Cost (S$)	CO2 emission (tonnes)
Steam	*6,300*	90%	7,000	492,100	1,300
Electricity	*12,900*	1	12,900	2,751,500	6,920
Chilled water	*3,850*	5	770	164,400	410
Hot water	*2,700*	98%	2,700	192,000	50
	Total			**3,600,000**	**9,130**

Generator sized to meet steam Demand

Tri-generation System

Primary energy (Input)

	% PE	Power (MW)	Consumption per year (MWh)	NG Cost (S$)	CO2 emission (tonnes)
Natural Gas	100%	8.78	69,200	4,862,000	12,740

Energy Production

Energy (Output)	% PE	Power (MW)	COP/Extra Usage (MW)	Yearly production (MWh)
Electricity	41%	3.60	0.16	*27,100*
Steam	18%	1.60		*12,600*
Chilled water	16%	1.40	0.7	*7,700*
Hot water	4%	0.34		*2,700*
Losses	21%	1.84		*14,500*
	100%	8.78		

Conventional System (separate production)

	Consumption (MWh/year)	Efficiency/COP	Energy (MWh/year)	Cost (S$)	CO2 emission (tonnes)
Steam	*12,600*	90%	14,000	984,000	2,580
Electricity	*27,100*	1	27,100	5,771,000	14,500
Chilled water	*7,700*	5	1,550	328,800	830
Hot water	*2,700*	98%	2,700	192,100	500
		Total		**7,275,900**	**18,410**

Comparison

	Sized to meet hot water demand	Sized to meet steam demand
Energy Cost saving (S$/yr)	1,170,000	2,413,900
CO_2 Reduction (Tonnes/yr)	2,760	5,670
Annual O&M Cost (S$/yr)	200,000	200,000
CAPEX Budget Forecast (S$)	5,280,000	10,560,000
Payback Period (years) (Including O&M cost)	5.4	4.8
Payback Period (years) (Excluding O&M cost)	4.5	4.4

Observations

- Technology is an integral part of the evaluation
    - Micro-turbine vs gas turbine vs gas engine

- There are multiple utilities to evaluate
    - Steam (heat), hot water, chilled water, dehumidification, electricity

- Each combination has implications on cost, savings, flexibility, carbon footprint, primary energy requirements

Observations

- **Selection process is complex and needs to be matched to facility specific requirements**

- **Life-cycle analysis / cost-benefit analysis is equally complex and requires greater sophistication and detailed sensitivity analysis**
  - **Spark spread may vary over time, so ability to hedge market electricity prices will also vary**
  - **Offsetting cost of producing steam and other utilities has a bearing on overall project economics**
  - **Once investment is sunk, marginal operating cost considerations take over**

Observations

- Sizing the plant is often key
  - Steam (heat) demand as sizing parameter appears most critical for best project economics and lowest carbon emissions
  - If heating demand varies, storage options should be considered to smooth requirements for better plant utilisation; same cannot be said with certainty for chilled water
  - Relationship between desired steam parameters, technology, costs not well understood

Observations

- Confusion arises when overall thermodynamic efficiency is a consideration in decision making

- Meeting cooling requirements, i.e. chilled water, dehumidification, usually turn out to be of incidental concern

- Same can be said for hot water

- Sizing for electricity requirement results in waste heat not being fully utilised and higher carbon emissions

Observations

- All parasitic loads must be considered in evaluations
    - Auxiliary pumps, fans, gas booster pumps, etc

- Suitability of town gas for cogen or trigen is questionable – small spark spread, difficult fuel to manage

- Evaluate all this while keeping an eye on the electricity market regulatory environment

Thank you

Information on
energy efficiency initiatives of E^2PO is available at
www.e2singapore.gov.sg