Sustainable Development Initiatives of Power, Cooling and Water in UAE Energy-intensive Industrial Facilities

Clean Energy R&I Collaboration and Funding Opportunities Workshop
Session 2: Enhancing Clean Energy R&I Synergies

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Outline

• **Background**
  • Context and Motivations for Energy Savings in GCC Energy-intensive Industrial Facilities
  • Energy Performance Improvements Approaches in GCC Energy-intensive Industries

• **Examples Waste Heat Recovery based Schemes for GCC Hydrocarbon Production Facilities**
  • Tri-generation for Process Gas Heating and Cooling, and Gas Turbine Power Generation Capacity Enhancement using Waste Heat
  • Propane Refrigeration Cycle Enhancement using Waste Heat Activated Absorption Refrigeration
  • Combined Gas Turbine-Organic Rankine Cycle coupled with Reverse Osmosis Seawater Desalination

• **Clean Energy R&I Activities and Synergies for GCC Energy-intensive Industries**
Context and Motivations for Energy Savings in GCC Energy-intensive Industrial Facilities: Energy Demand and Economics

- Global energy consumption projected to grow by 36% between 2010 and 2030
- Fossil fuels will still provide 80% of global energy supply in 2035, and 60% of supply growth
- For Middle East energy production to grow and be exported, energy efficiency requires to improve locally – gas conservation
- Middle East energy consumption growth driven by industry (e.g., oil and petrochemicals, (L)NG, cement, iron/steel, aluminum) and power generation

[Source: BP, 2012]

- High CO₂ emissions per capita
- Electricity and water production single largest source of UAE emissions, followed by energy-intensive industries, including oil/gas

**CO₂ emissions per capita**
[Source: World Bank, 2013]

**CO₂ emissions in Abu Dhabi’s Emirate**
[Source: Abu Dhabi’s Environment Agency, 2013]

Exhaust gas waste heat recovered from five 27 MW GTs for GT compressor inlet air cooling, process gas cooling and lean gas heating

Key findings:
• Recovery of 82 MW of GT waste heat would provide:
  — 151 GWh additional electric power over a complete year and 38.5 MW in peak GT cooling load conditions, through GT compressor inlet air cooling
  — Additional cooling and heating capacities of 75 MW and 24 MW, respectively, thereby permitting elimination of a 28 MW GT, and existing air-coolers and three direct heating furnaces, while reducing propane chiller cooling load
• Annual OC savings ~ 15 million USD
• NPV, IIR and SPBT ~ 158 million USD, 39% and 3 years, respectively

Propane Cycle Enhancement using Waste Heat Activated Absorption Refrigeration

GT waste heat recovered using absorption chiller for enhancement of APCI pre-cooled multi-component refrigerant (MCR) cycle cooling capacity and COP

COP and total cooling capacity enhanced by 13% and 23%, respectively

- a) Cycle enhanced by subcooling propane after the condenser by 21°C

- b) Cycle enhanced by reducing condenser pressure through pre-cooling of condenser cooling water from 35°C to 15°C, using either fresh or sea water

Combined Gas Turbine-Organic Rankine Cycle coupled with Reverse Osmosis Seawater Desalination


Key Findings

- GT-toluene ORC thermal and exergy efficiencies of 39% and 37%, respectively
  - ~ 12% gain in power generation thermal efficiency with addition of bottoming toluene ORC to existing GT cycle
- GT-toluene ORC-RO exergy efficiency: 29%
- Desalinated water production: 2,260 m³/h
- Annual OC savings ~ 23 - 35 million USD
- NPV, IIR and DPBT ~ 233-380 million USD, 26-48% and 2-4 years, respectively

Co-generation system of electric power and desalinated water

Predicted key IHE–ORC waste heat recovery system operating parameters at yearly-average ambient conditions.

| ORC fluid | $T_\text{T} (°C)$ | $w_{\text{g, gross,ORC}} (\text{kJ/kg})$ | $m_{\text{ORC}} (\text{kg/s})$ | $W_{\text{net,ORC}} (\text{MW})$
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Note: $T_\text{T}$ refers to ORC turbine inlet temperature. $w_{\text{g, gross,ORC}}$ refers to ORC specific gross power output. $W_{\text{net,ORC}}$ refers to ORC net power output.
Suggestions for Clean Energy R&I Activities for GCC Energy-intensive Industries

• Waste heat recovery, co/tri/multi-generation and coupling of distributed power and desalination in GCC energy-intensive industrial facilities can be implemented:
  o Using commercially-available, affordable technologies
  o At low risk, with minimal disturbance to existing core processes

• …and have the potential to bring significant improvements in:
  o Energy/exergy efficiency
  o Annual operating cost savings associated with gas and/or water savings
  o Capital equipment savings (e.g., elimination of power/cooling equipment) through efficiency enhancements
  o Reduced emissions

• The energy enhancement approaches presented are generically applicable to other waste heat sources, applications/end-uses and energy-intensive facilities
Suggestions for Clean Energy R&I Activities for GCC Energy-intensive Industries

• **Waste heat utilization** R&D activities:
  o Energy audits that include compilation of existing waste heat sources (rate, grade, distribution/location)
  o Evaluation of possible waste heat end uses
  o Mapping of waste energy sources, potential end uses and available heat recovery technologies
  o Techno-economical-environmental, space and safety assessments of candidate schemes/solutions

• **Other** R&D activities:
  o Renewable integration
  o **Long-term planning/development** of smart energy systems, including industrial, district, water, and electricity/gas grid development
Suggestions for Clean Energy R&I Synergies

• To enable long-term development of smart energy systems, more national/regional funding programs required enabling collaborative GCC research
  o Identify GCC research priorities
  o Focus on solutions enabling integrated / smart energy systems
  o Avoid research redundancies and incremental research
  o Draw from, and adapt from EU-funded research outcomes
    > GCC programs open to EU partners
    > Open specific EU-GCC research funding programs?

• Improve synergy between universities at national level, for more effective utilization of capital & human resources, towards common goals

• Increase GCC academic staff time for research

• Increase communication between academia and industry

• EU research partners to account for GCC research practices (e.g., project timelines, project/expenditure approval processes)

• Non-funded R&I EU-GCC activities: e.g., collaborative work/publications, exchange of visiting research personnel
Thank you for your attention