Design and optimization of CCHP for microgrids and solar energy buildings

Dr. Arun Kumar Vaiyapuri
Project Manager- R&D and Renewable Energy
STEAG – Shareholder Structure

<table>
<thead>
<tr>
<th>Name</th>
<th>Shareholding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stadtwerke Duisburg</td>
<td>19%</td>
</tr>
<tr>
<td>Stadtwerke Essen</td>
<td>15%</td>
</tr>
<tr>
<td>Stadtwerke Dinslaken</td>
<td>6%</td>
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<tr>
<td>Dortmund Stadtwerke</td>
<td>36%</td>
</tr>
<tr>
<td>Stadtwerke Bochum</td>
<td>18%</td>
</tr>
<tr>
<td>Energieversorgung Oberhausen</td>
<td>6%</td>
</tr>
</tbody>
</table>

STEAG Energy Services
# STEAG Portfolio overview

## Existing business activities

### Energy Technologies
- Design, planning and operation of power plants

### Nuclear Technologies
- Planning, construction and dismantling of nuclear facilities

### Plant Services
- Operation and maintenance services for thermal power stations, especially gas fired ones

### System Technologies
- Development, sale and implementation of O&M management and energy management tools

## Strategic projects

### “Asset Light” projects
- Minority investments in combination with international O&M contracts

### International wind and solar projects
- Identification and evaluation
STEAG International Presence

**SUBSIDIARIES**

**STEAG Energy Services GmbH**
Essen, Germany
Established in 1937

**STEAG Energy Services Schweiz GmbH**
Zurich, Switzerland
Established in 2014

**STEAG Energy Services Solar S.L.U.**
Seville, Spain
Established in 2012

**STEAG SCR-Tech, Inc. (JV 50%)**
Kings Mountain (North Carolina), USA
Established in 2016

**STEAG Energy Services do Brasil Ltd.**
Rio de Janeiro, Brazil
Established in 2002

**STEAG EOH Energy Services (Pty) Ltd. (JV 50%)**
Johannesburg, South Africa
Established in 2016

**STEAG Energy Services Botswana (Pty) Ltd.**
Gaborone, Botswana
Established in 2014

**STEAG Ensida Energy Services Ltd.**
Ankara, Turkey
Established in 1996

**STEAG Energy Services (India) Pvt. Ltd.**
Noida, India
Established in 2001
STEAG’s proven track record for future success

1937 Foundation of STEAG

1996
- Leuna (Germany)
  - 162 MW Refinery
1998
- 165 MW Hard coal
2000
- Termopaipa (Colombia)
- 1,320 MW Hard coal
2002
- Illmenau (Germany)
  - 5 MW Biomass (1)
2004
- Iskenderum (Turkey)
2006
- Mindanao (Philippines)
  - 232 MW Hard coal
2009
- Karstädt (Germany)
  - 1 MW Biogas (1)
2010
- Kohlscheid (Germany)
- Walsum 10 (Germany)
2012
- Leuna (Germany)
- 1,320 MW Hard coal
2013
- Ridham Dock (UK)
  - 25 MW Biomass

About 8,000 MW commissioned in the Rhine-Ruhr and Saar regions
STEAG holds a strong position in the renewable energy market

- **Sites of Steag New Energies GmbH**
- **Subsidiaries**

**STEAG Projects**

**Wind**
- 306 MW total in Germany, Romania, France (Operating >500 turbines)

**Solar**
- 30 MW Solar PV O&M at Telangana
- 300 kWp Rooftop at Holy Family Hospital microgrid.
- 20 Kwp Rooftop at St. Mary School at Rothak microgrid.

**Biomass**
- since 2002
- #3 in Germany

**Biogas**
- since 2007
- First own biogas plant commissioned

**Mine gas**
- since 1908
- #1 in Germany

**Geothermal**
- since 1994
- #1 in Germany

**Contracting**
- since 1961
- #2 in Germany

**Total**
- Sites of Steag New Energies GmbH
- Subsidiaries

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Installed capacity</th>
<th>Plants</th>
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<tbody>
<tr>
<td>Biomass*</td>
<td>MW&lt;sub&gt;el&lt;/sub&gt; 66</td>
<td>MW&lt;sub&gt;th&lt;/sub&gt; 154</td>
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<tr>
<td>Biogas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mine gas</td>
<td>MW&lt;sub&gt;el&lt;/sub&gt; 177</td>
<td>MW&lt;sub&gt;th&lt;/sub&gt; 139</td>
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<tr>
<td>Geothermal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contracting</td>
<td>MW&lt;sub&gt;el&lt;/sub&gt; 77</td>
<td>MW&lt;sub&gt;th&lt;/sub&gt; 905</td>
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<tr>
<td><strong>Total</strong></td>
<td>MW&lt;sub&gt;el&lt;/sub&gt; 319</td>
<td>MW&lt;sub&gt;th&lt;/sub&gt; 1,271</td>
</tr>
</tbody>
</table>
Typical Microgrid

- Diesel Generator
- Solar PV
- Load
- Biomass
- Grid

SHC TASK 86
Solar Energy Buildings

Mittwoch, 28. September 2022
Dr. Arun Kumar Vaiyapuri
Approach

Identification of Project/Case study

Data Collection (Load, Generation, environmental parameters etc.)

Identification and possibility of accurate measurements

Optimization and effective utilization of Renewable Energy (solar energy)
Figure: System model of the proposed rural off-grid system
Different BESS options for microgrid

- Flooded LA
- VRLA (Tubular Gel)
- Li-ion
Key Parameters/Data

Combination of primary and secondary Data

Primary Data
- Solar Irradiation
- RE Resources
- Electric Load
  - Heating
  - Cooling
- Thermal Load
- Heating
- Cooling
- Site constraints
- Uncertainty
- Economic constraints
- Reliability

Secondary Data
- Assessment methodology
- Data analysis
- Accuracy of data and measurements
- Duration of Data
Data Collection

• Load Pattern
  1. Electric Load Pattern
     • Typical loads
     • Variation pattern
     • Impact on load – Seasonal

  2. Thermal Load Pattern (Combined Cooling and Heating (CCHP))
     • Cooling load
     • Heating load including hot water load

• Climatic Conditions
  • Temperature
  • Humidity

• Solar Radiation Data
  • GHI
  • DNI (Wherever heat is considered)
Optimal Sizing

Microgrid Planning

- Inputs: Solar data, biofuel data, load data, Cost parameters
- MILP based optimal sizing formulation
- MILP optimization process using GLPK solver
- Outputs: Optimal size of PV, Bio, BESS and DG-set

Energy Balance

- Asset Configuration (Solar, Biomass, BESS, DG-set)
- Hourly Dispatch Analysis
- Hourly dispatch Schedule
- Hourly generation data and load data, SOC seasonal variation

Economic Analysis

- Input: Cost data
- Economic Analysis and Co2 Analysis
- Output: LCOE, NPV and Carbon saved
Table: Case Study details

<table>
<thead>
<tr>
<th>Case study</th>
<th>Description</th>
<th>Location</th>
<th>Grid availability</th>
<th>Alternate Source</th>
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</thead>
<tbody>
<tr>
<td>Case 1.</td>
<td>Holy Family Hospital (HFH)</td>
<td>Delhi</td>
<td>Good</td>
<td>DG-set</td>
</tr>
<tr>
<td>Case 2.</td>
<td>St. Mary school (SMS)</td>
<td>Rohtak</td>
<td>Very Poor</td>
<td>DG-set</td>
</tr>
<tr>
<td>Case 3.</td>
<td>St. Mary Hostel (SMH)</td>
<td>Rohtak</td>
<td>Very Poor</td>
<td>DG-set</td>
</tr>
<tr>
<td>Case 4.</td>
<td>Green Urja (GU)</td>
<td>Gorakhpur</td>
<td>Poor</td>
<td>DG-set</td>
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<tr>
<td>Case 5.</td>
<td>Rajagiri college of social science (RCSS)</td>
<td>Cochin</td>
<td>Good</td>
<td>DG-set</td>
</tr>
</tbody>
</table>
Case Study-RCSS

DG1-320 kVA

DG2-500 kVA

GRID SOURCE-1

GRID SOURCE-2

DG3-500 kVA

OTHER LOADS

CARMEL BLOCK

RCSS OLD BLOCK

AC

Power in kW

Hour of day

SWD
SWE
SMWHD
SMWWE
Case study-RCSS

CASE STUDY

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Case Study - SMS and SMH

LEGEND:

- MCB (MINIATURE CIRCUIT BREAKER)
- MCCB (MOULDED CASE CIRCUIT BREAKER)
- CT (CURRENT TRANSFORMER)
- CHANGE OVER SWITCH
- ENERGY METER
- CHANGE OVER
Case Study-SMS and SMH

Figure: Load Pattern of School

Figure: Load Pattern of Hostel
Brief Contents

Introduction

CCHP for Micro-Grids and Solar Energy Buildings

Key Parameters/Inputs

Optimization of CCHP

Case Studies of CCHP

Conclusion
Conclusion

- **Summary of key steps for a successful implementation of CCHP in Microgrids or individual entities**

  - Accurate Data collection with more long term data
  - Design and optimization of complete system with system constraint
  - Techno-Economic optimization with financial constraints
  - Effective implementation with latest technology
  - Industrial best practice O&M implementation

- **Advanced level scope**
  - Budget constraint optimization
  - Generation and load expansion planning
  - Effective storage
  - Community level participation in energy transfer and optimum management system
For more information feel free to contact us:

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Thank You