Going Off-grid: The Business Case for Off-grid Industrial Microgrids

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Senior Engineer Specialist: Studies

Structure

- Problem Statement
- The Energy Trilemma
- What is a Microgrid?
- Microgrid Feasibility Analysis Process
- Case study
- Analysis of Energy Needs
- Identification of DERs
- Techno-Economic Model and Financial Analysis
- Technical Consideration
- Risks
- Conclusions

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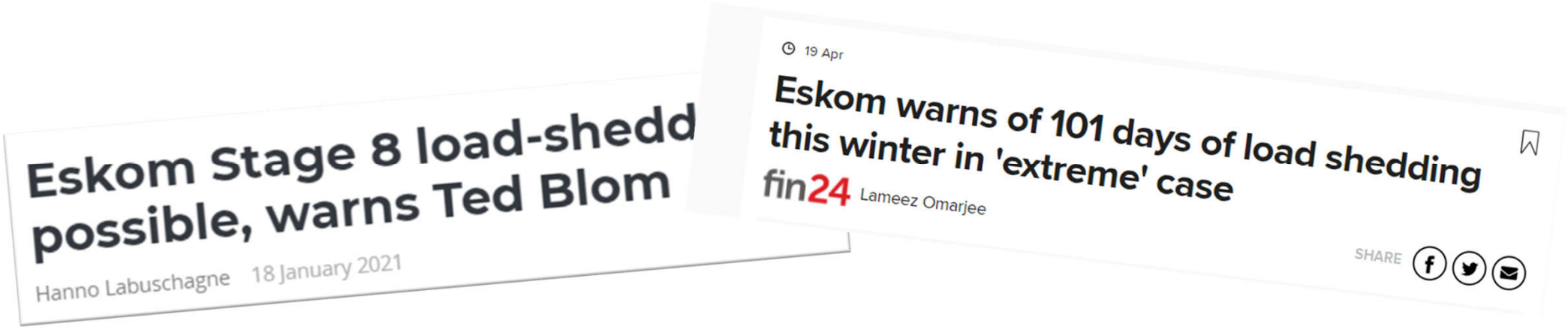
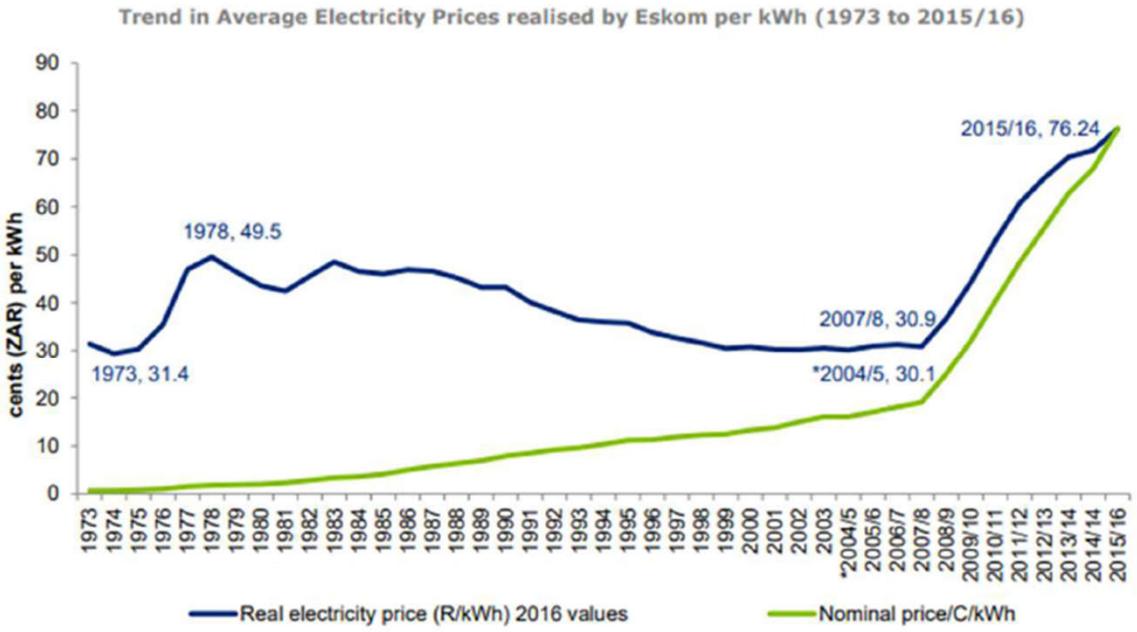
Problem Statement – 1 – Reliability of the Grid

- Load shedding
- Several customers are subject to frequent power supply interruptions
- Power quality or Quality of Supply issues (e.g. voltage dips)

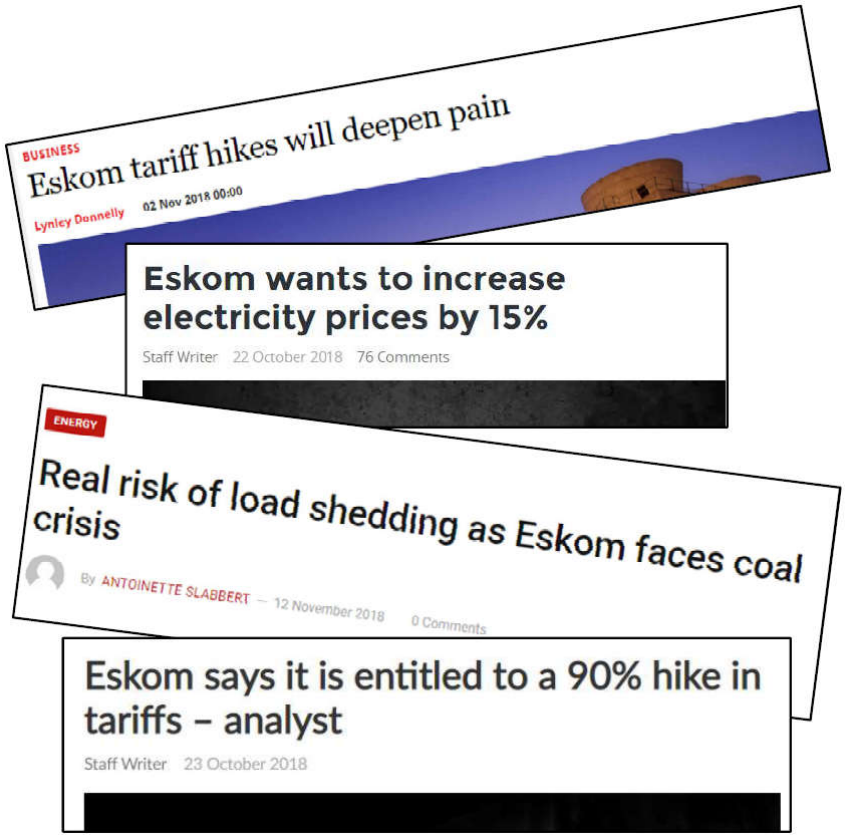
These electrical issues hinder the ability of industries to meet their commitments to their clients due to the loss of production, resulting in financial losses.



Problem Statement – 2 - Electricity Costs



Source: Deloitte Analysis, Eskom data and 2011 annual report
Note: In 2004/5 Eskom change financial year from calendar year (year-ending 31 December) to year-ending 31 March



Proconics

Problem Statement – 3 – Pressure to Reduce Carbon Footprint

- Global pressure to improve sustainability and reduce carbon footprint
- Financial incentives such as carbon tax measures as well as public relations incentives.

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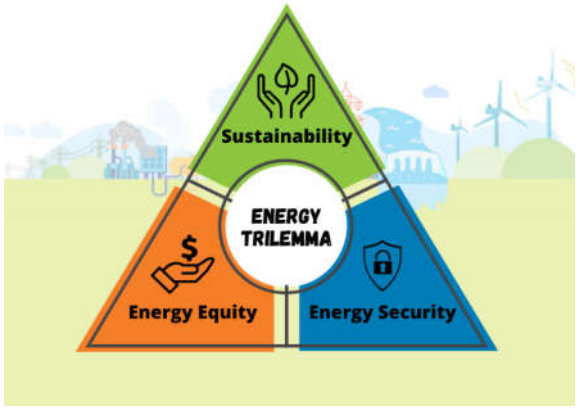
The energy trilemma

- The previous problem statements can be paraphrased as follows:
  - Problem statement 1: Energy security
  - Problem statement 2: Energy equity
  - Problem statement 3: Sustainability
- This is known as the energy trilemma



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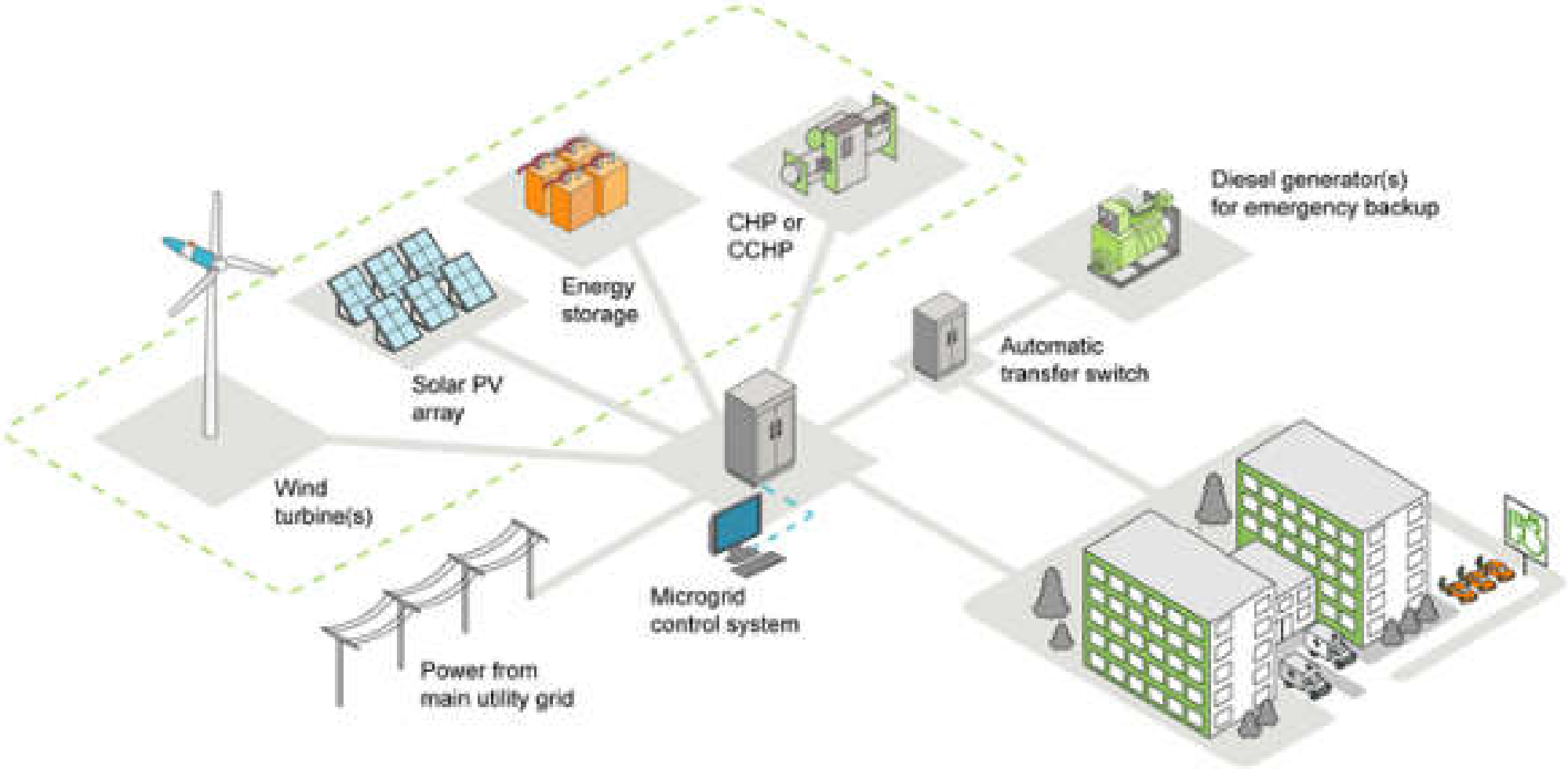
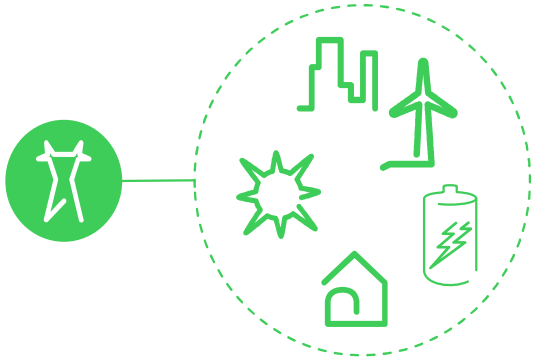
What is a Microgrid?



What is a Microgrid?

Optimize electrical bill & sustainability footprint

Hybrid system: Grid + local generation/storage + load management



Grid-tied

Manage blackouts while optimizing your electrical bill & sustainability footprint

Hybrid system: Grid + local generation/storage + load management

Islandable

“Power on” with efficient and future proof power systems

Hybrid system: Diesel/Gas &/or renewable generation + storage + load management

Off-grid

Proconics

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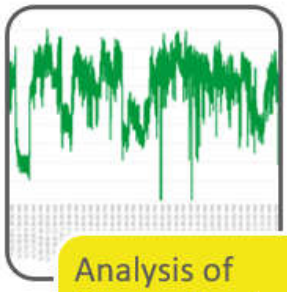
Microgrid Feasibility Planning Process (SATS/IEC62898)



Analysis of Energy Needs

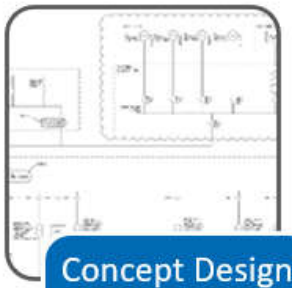
- All forms of energy
- Current
- Future

Identification of Distributed Energy Resources (DERs)

DER Analysis

- Cost
- Technical Limits

Techno-Economic Evaluation and Optimisation



Concept Design

- SLD
- P&ID

Hold Point 1 – Preliminary Study

- For client to confirm if understanding of existing structure, future considerations, objectives... is correct

Hold Point 2 – Option Selection

- Presents multiple microgrid configuration options and makes a recommendation of which to select. Client to confirm selection for further development

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Case Study

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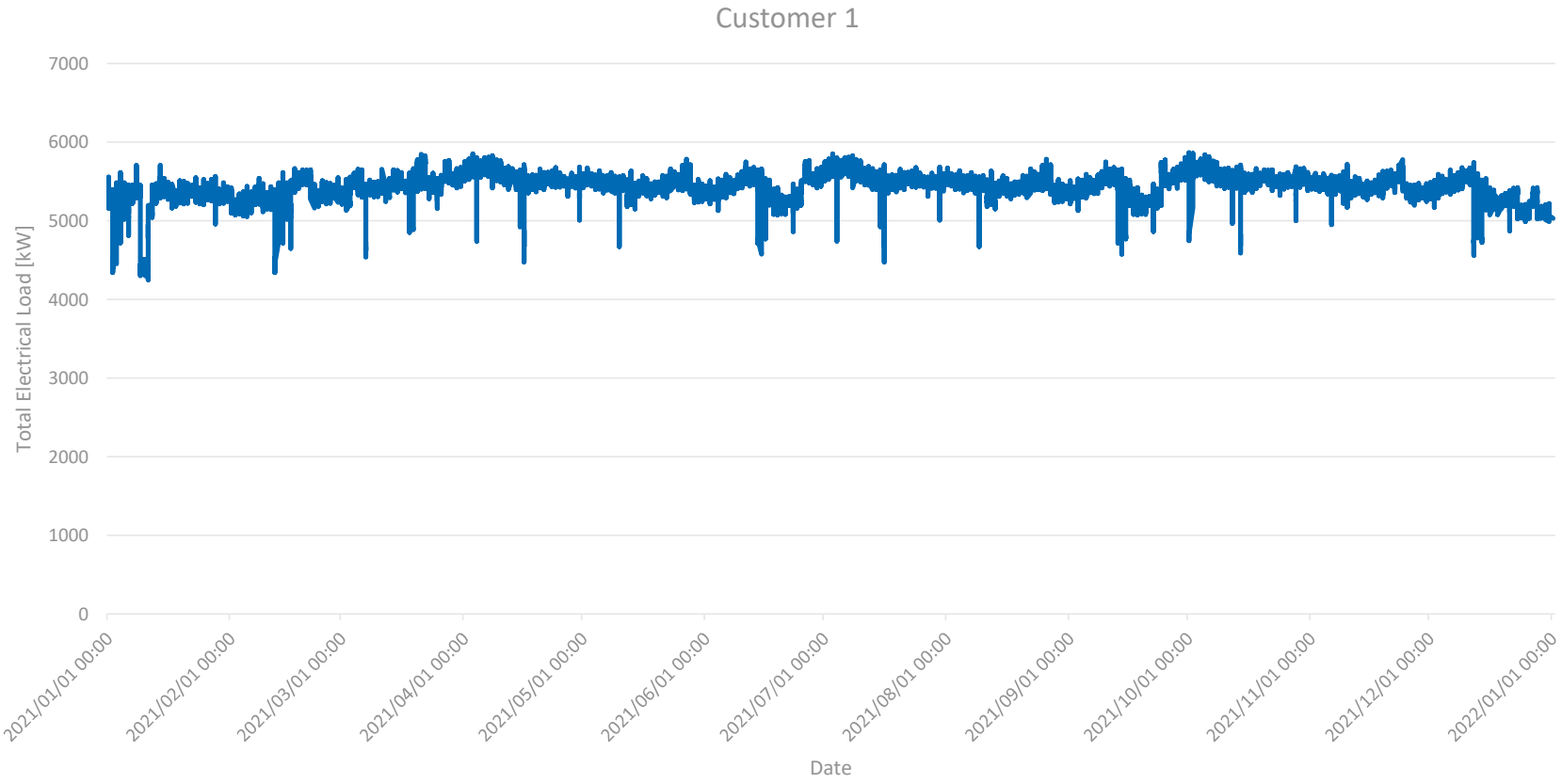
Analysis of Energy Needs

- Electrical Consumption Analysis
  - Two different customers form part of the case study.
    - Customer 1 is a 24/7 operation
    - Customer 2 is currently only on a day shift
  - Both customers will be connected to the same microgrid

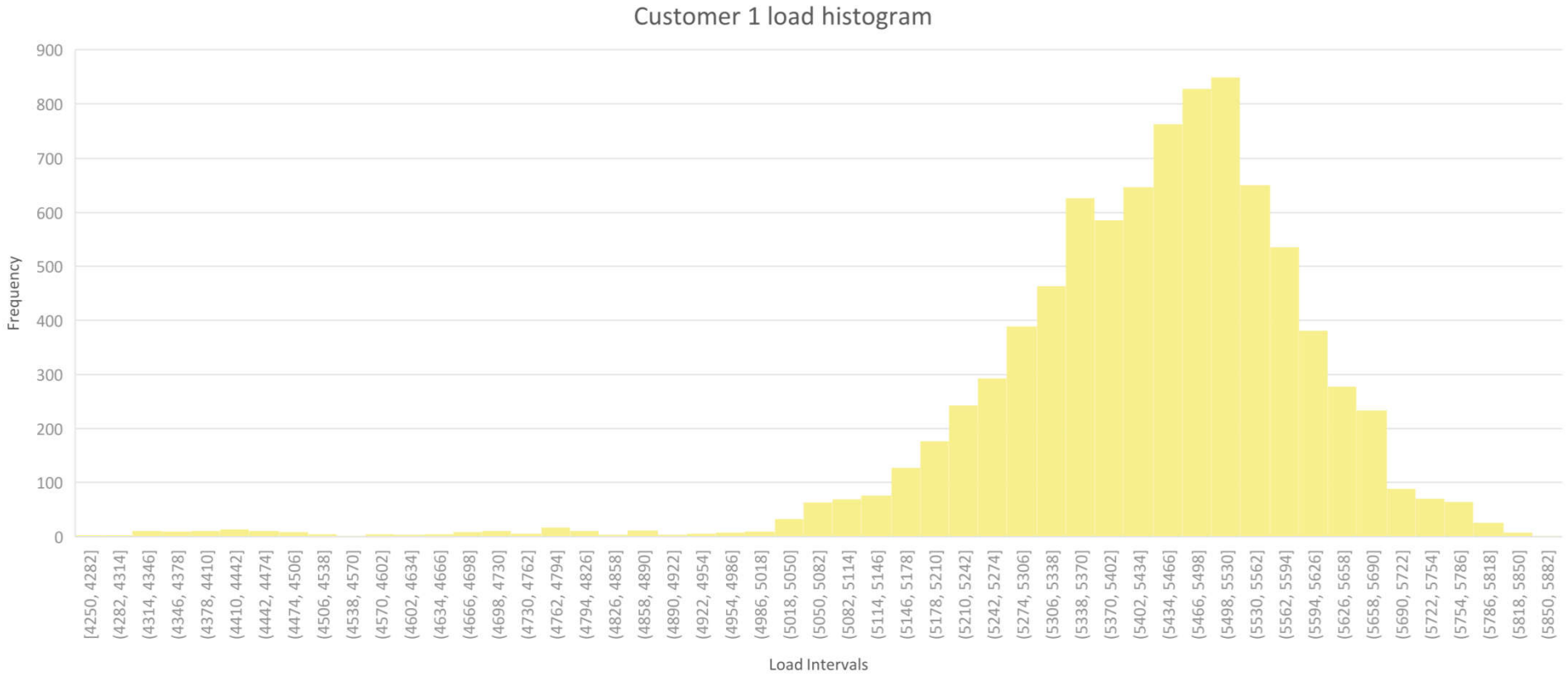
Analysis of Energy Needs

- Electrical Consumption Analysis – Customer 1



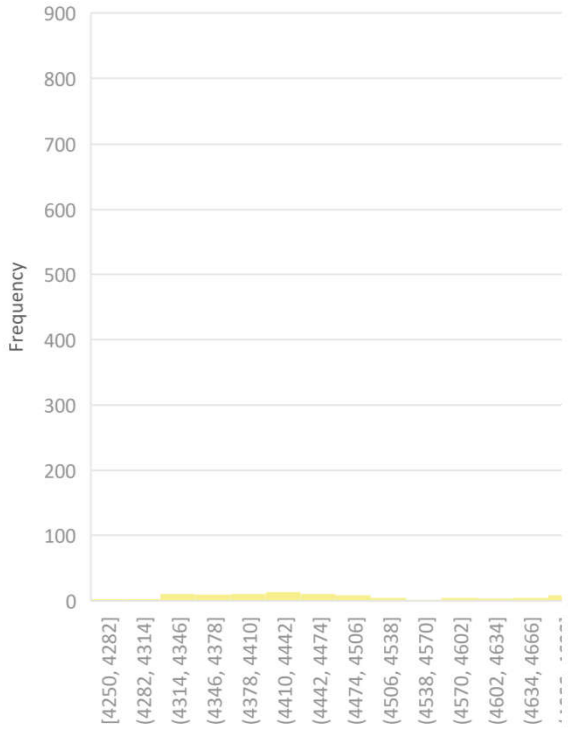
Analysis of Energy Needs

- Electrical Consumption Analysis – Customer 1



Analysis of Energy Needs

- Electrical Consumption A



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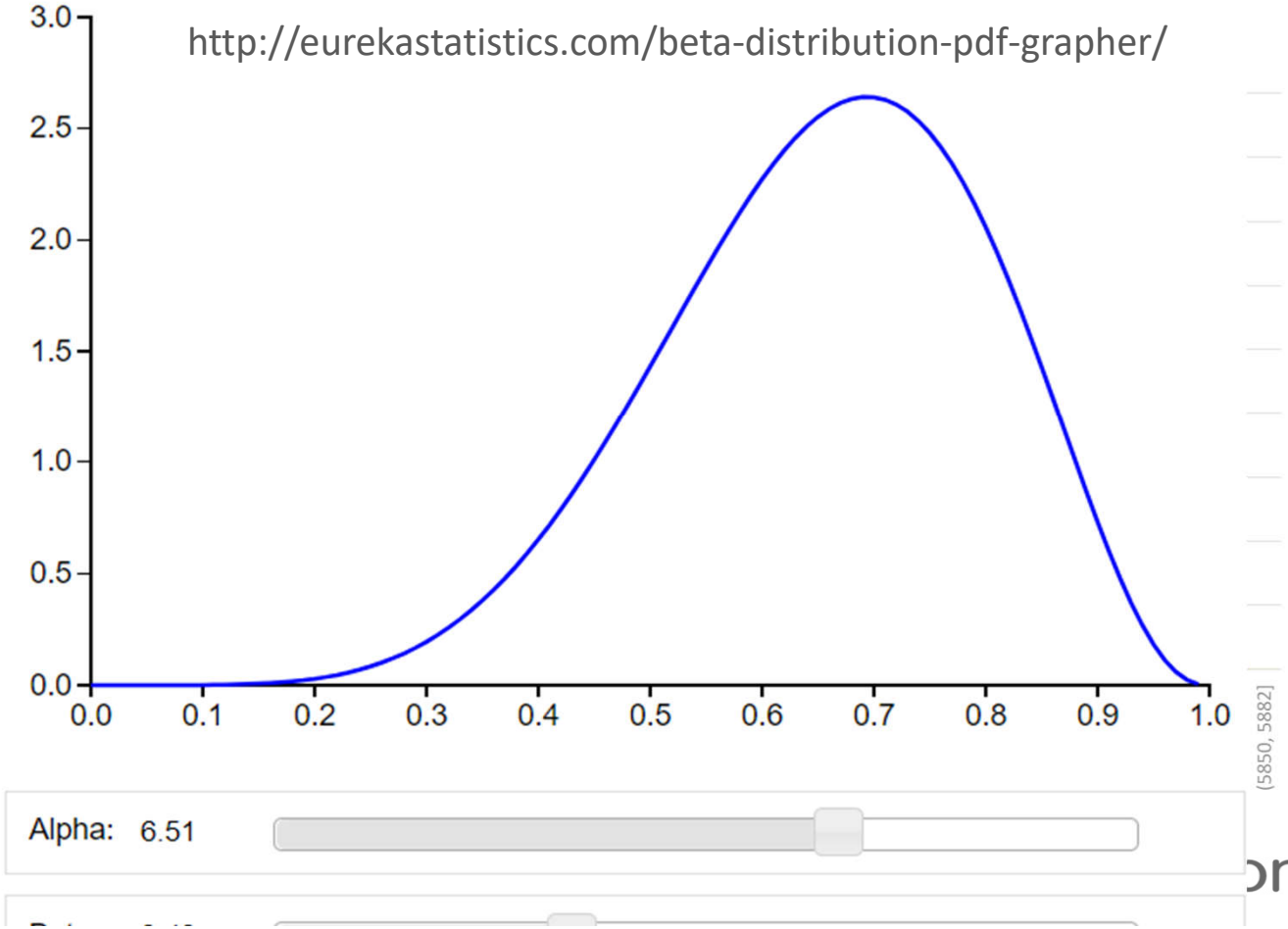

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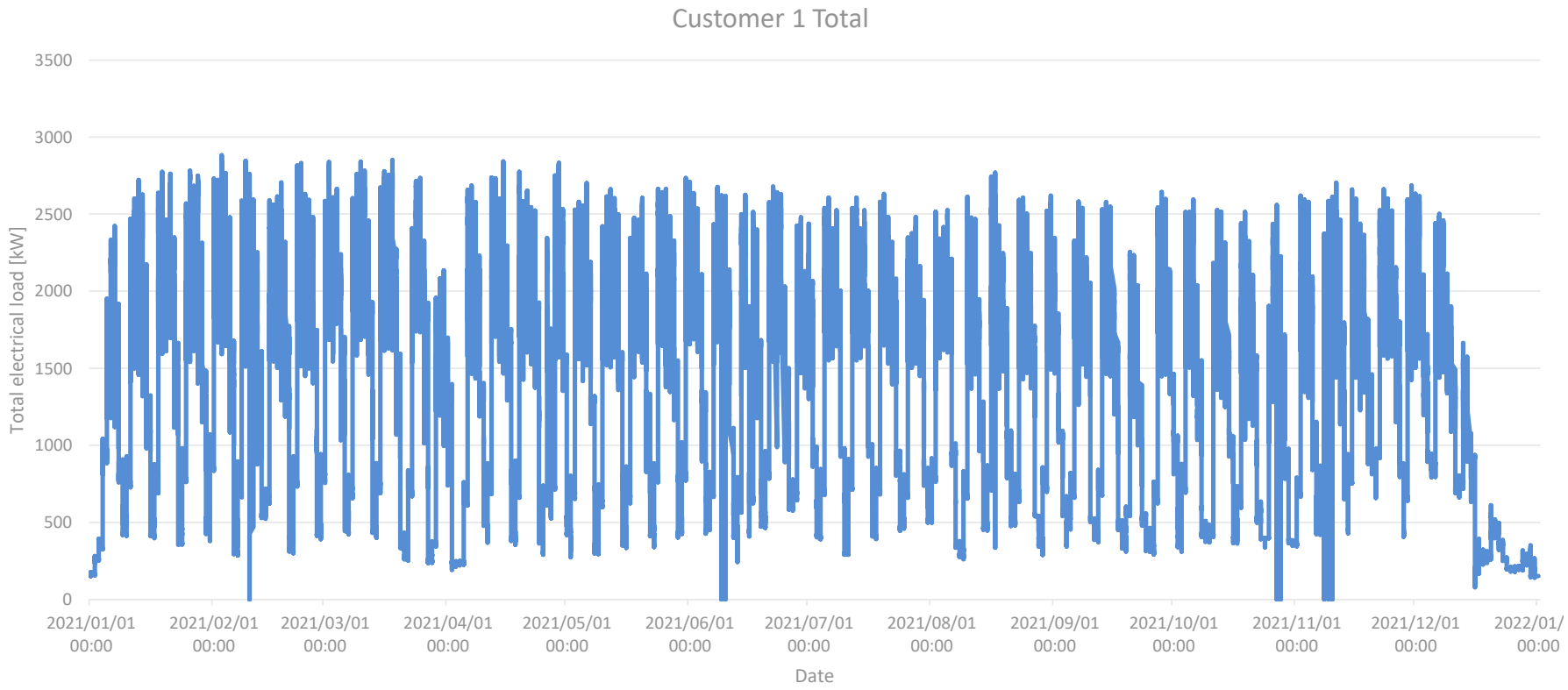
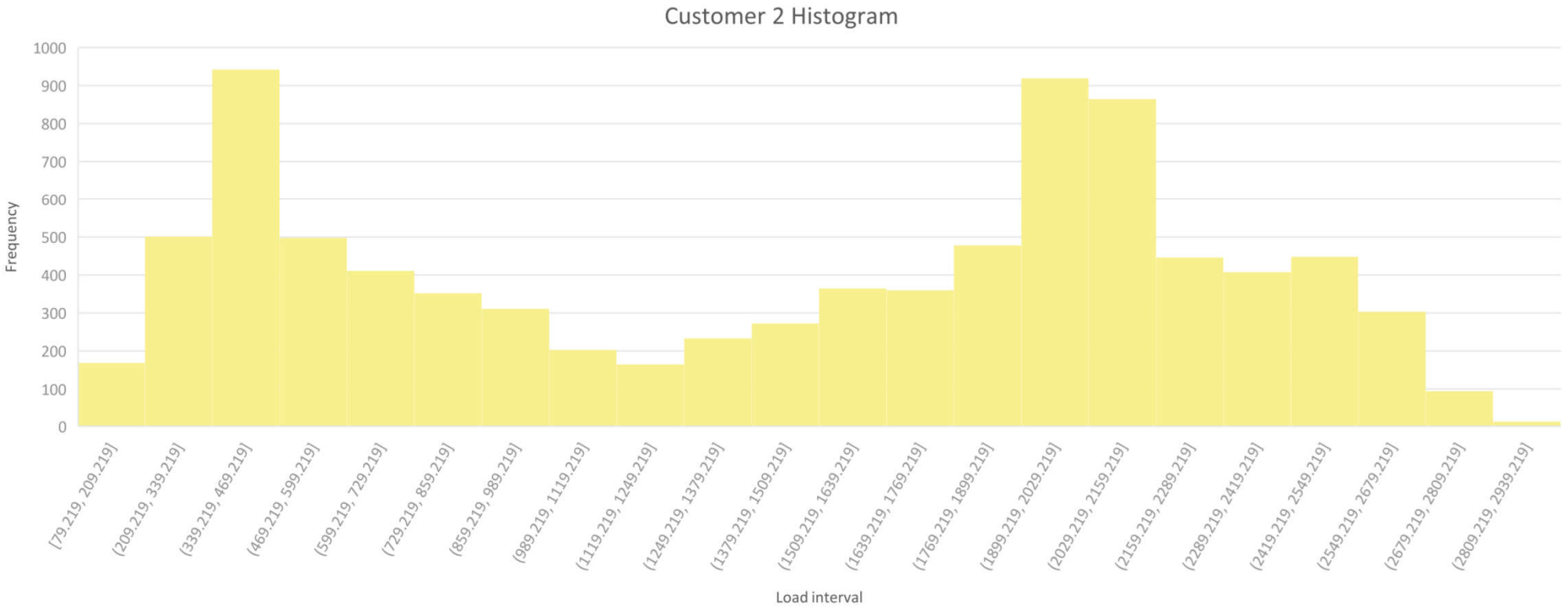
Analysis of Energy Needs

Electrical Consumption Analysis – Customer 2



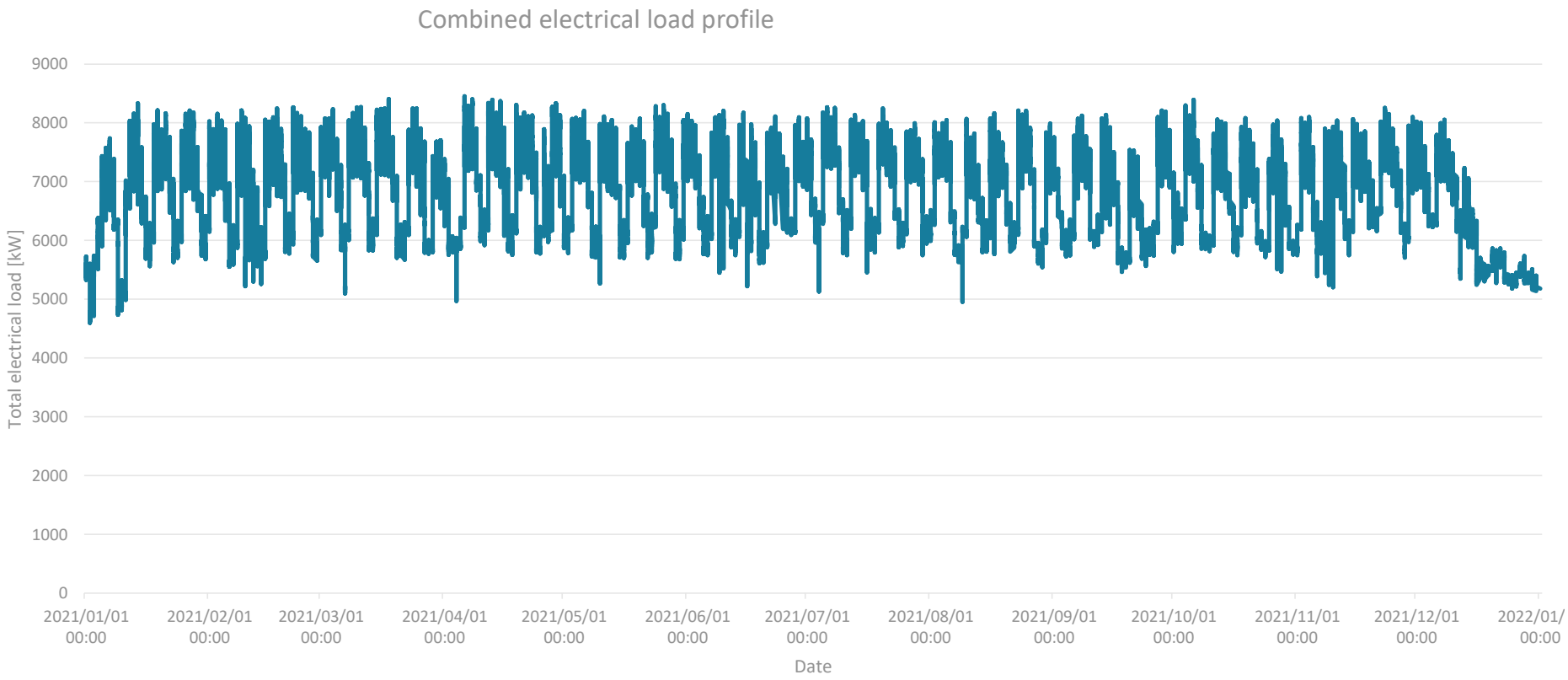
Analysis of Energy Needs

- Electrical Consumption Analysis – Customer 2



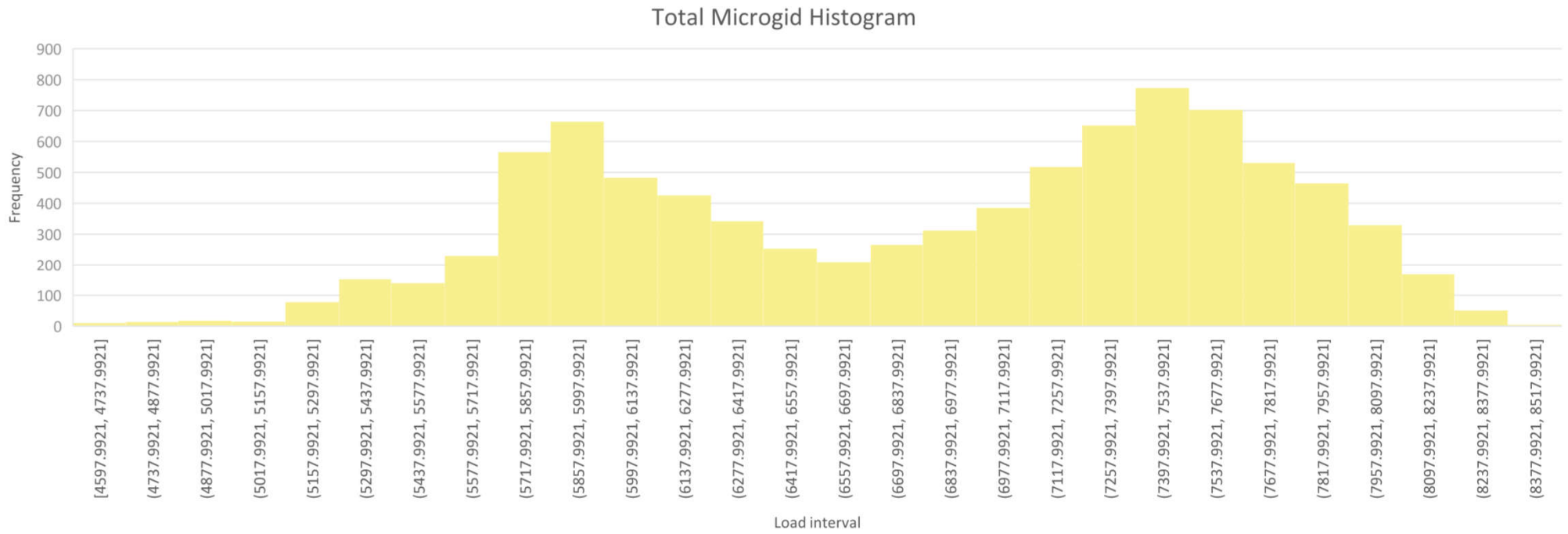
Analysis of Energy Needs

- Electrical Consumption Analysis – Total proposed microgrid



Analysis of Energy Needs

- Electrical Consumption Analysis – Total proposed microgrid



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Analysis of Energy Needs

- Gas Consumption Analysis
  - Both customers use gas for process heating
  - The detailed analysis was done by process engineers and is outside the scope of this presentation
- Several electrical chillers to produce chilled water

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Identification of DERs

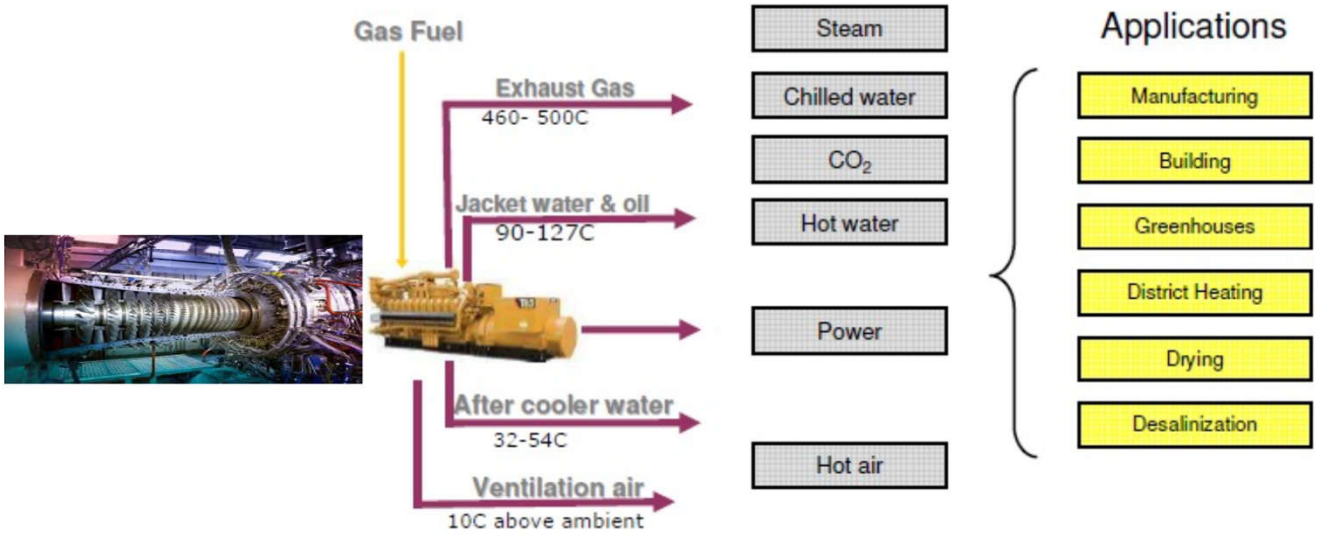
- Various DERs were looked at, the following DERs were identified as the more suitable options:
  - Solar PV
  - BESS – Battery Energy Storage System
  - CHP – Gas-powered Combined Heat and Power

Identification of DERs

- Solar PV Assessment
  - Customer 1 has about 900 kW_{ac} of solar capacity
  - Customer 2 has a large total roof area. Solar capacity – 3.8MW_{ac}
  - Separate studies were done in a PV tool
- Battery Energy Storage System (BESS Assessments)
  - Budget prices were obtained for Li-Ion storage solutions

Identification of DER

- CHP (Combined Heat and Power)
  - CHP Plants offer an alternate way for companies to meet their thermal and electrical requirements.



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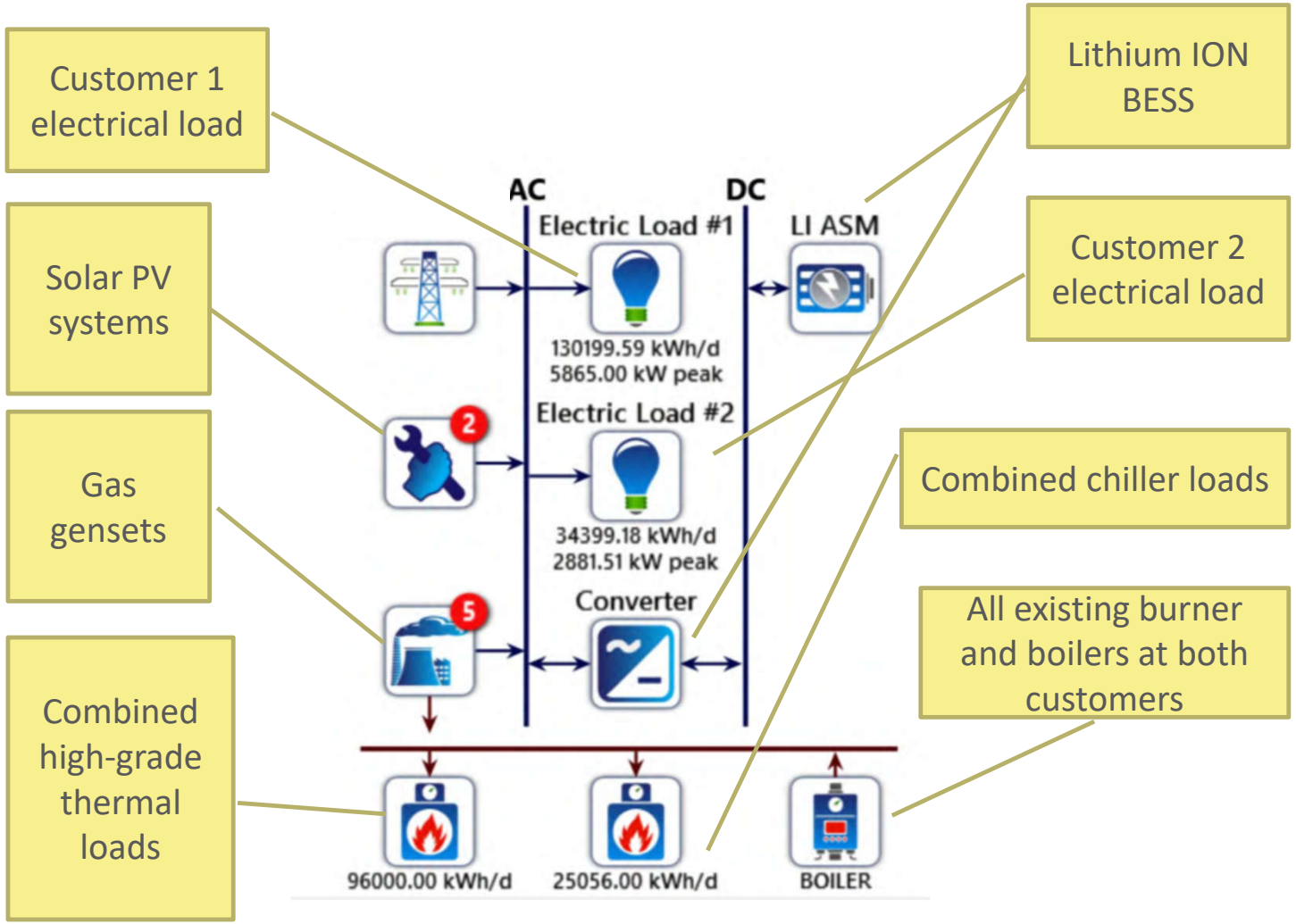
Techno-Economic Model and Financial Analysis

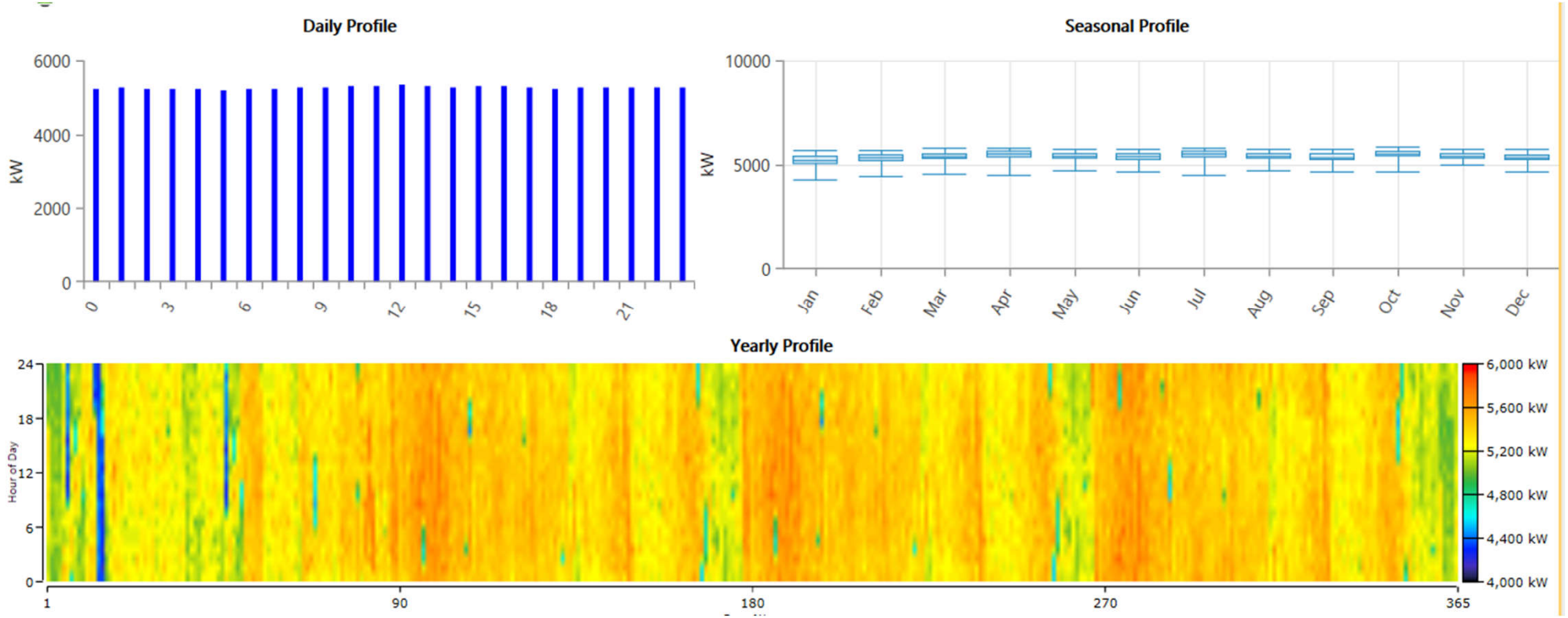
- We performed simulations on the system using different combinations of energy sources and storage, on an hourly basis for the entire project lifetime.
- We calculated various economic figures that are used for ranking the different options and comparing with the base system.
- This was largely automated using Homer Pro software

Microgrid Schematic

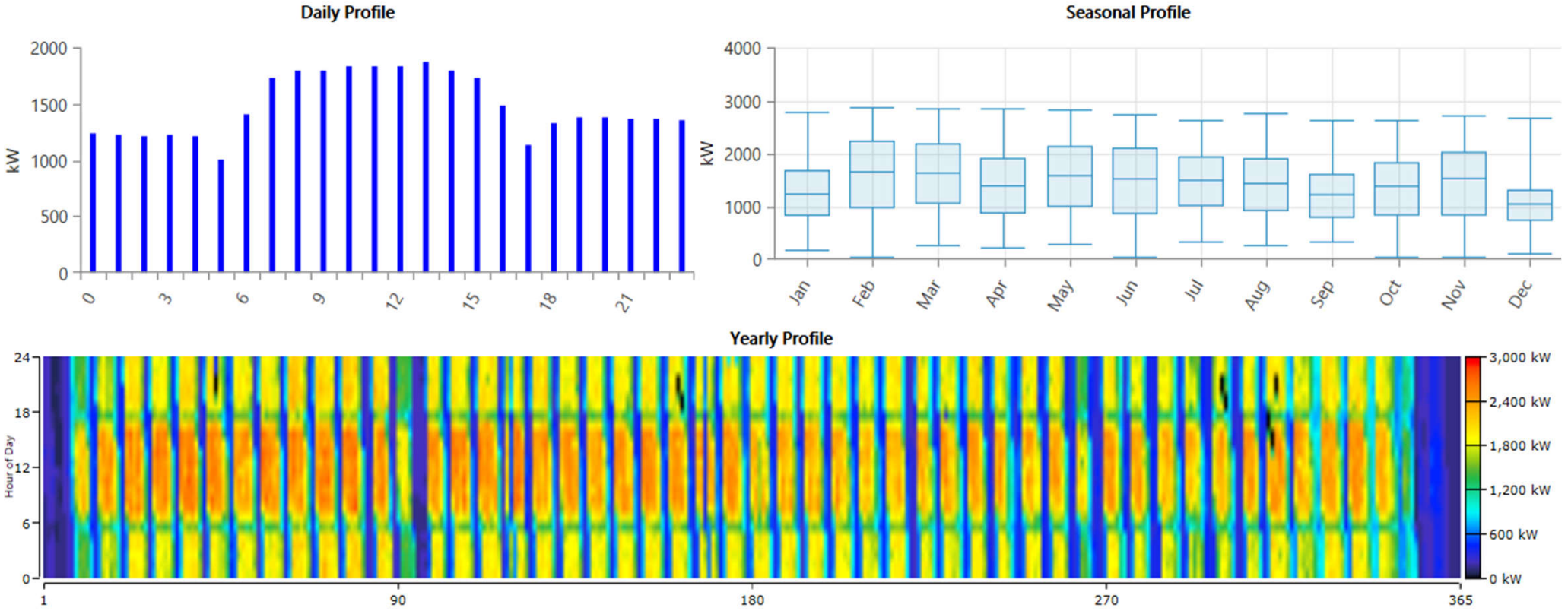


Proconics

Customer 1 Electrical Load

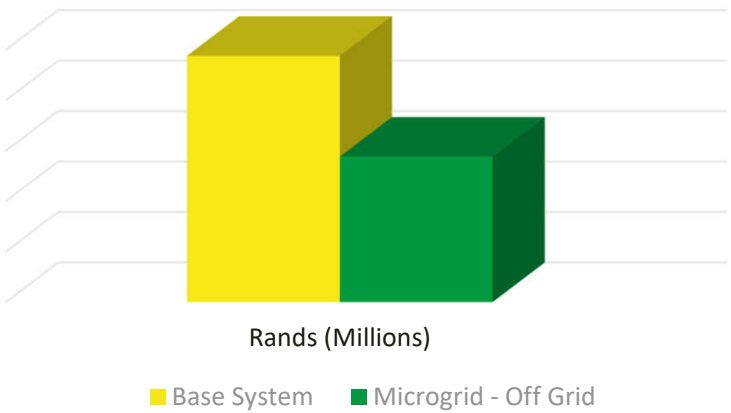


Customer 2 Electrical Load

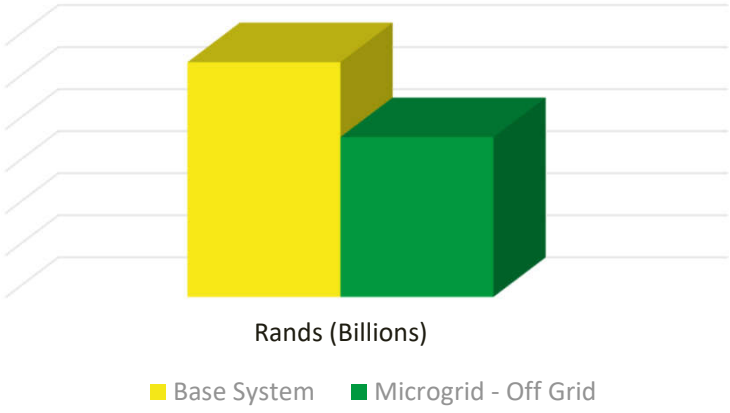


Combined microgrid– Feasibility Study Results

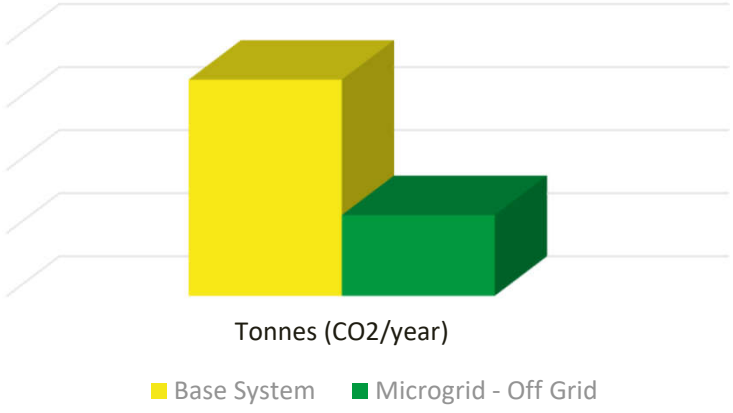
OPEX



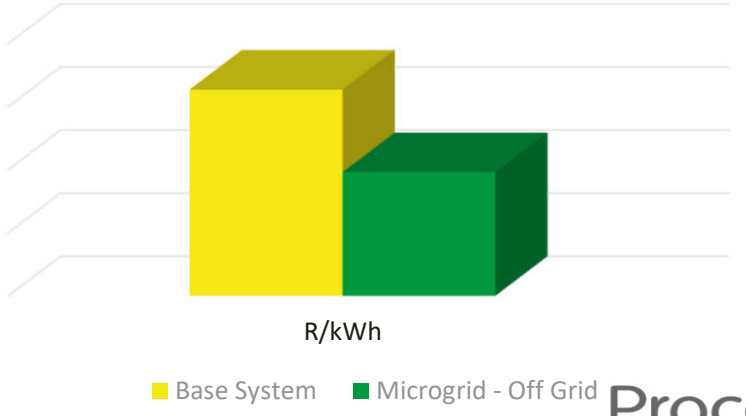
Net Present Cost



Carbon Emissions



LCOE – Levelised Cost of Electricity



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Combined microgrid – technical considerations

- For CHP microgrids, if the solar penetration is too high, it reduces efficiency of the system
- With increased gas prices, battery storage becomes more economical and grid-connected systems will only use the generators during peak periods.
- Our analysis does not include the cost of production losses due to grid QoS issues or outages. A system that does not seem viable at first glance, may still be attractive due this reduction in the resultant production losses.
- Unfortunately, a grid-connected microgrid of this size does not have enough inertia to smooth out the larger dips in the grid voltage. Suitable power electronics systems have proven not to be cost-effective in our case, but can be considered for other applications.
- Using the existing electrical supply only as a backup is usually unattractive because the network access charge and other fixed costs are still payable.

Risks

- Limited gas supply in South Africa and uncertainty of future availability
- Unknown effects of major global events on the price of natural gas, batteries and all other equipment.
- Step changes in load and PV output (due to clouds) may cause instability in the off-grid microgrid when renewable penetration is high
- Reduction in fault level will require the protection settings in the plant to be adjusted and grading will be harder

Conclusions

- Microgrids provide an attractive solution to improve reliability of supply, reduce energy costs and reduce the environmental impact of industrial electricity supplies.
- While there are advantages to remaining grid-connected, for some customers the risks outweigh the benefits.
- There is no single solution that is optimal in all cases. Each individual site has to be carefully analysed
- Off-grid microgrids are only feasible with when piped gas is available and is at a competitive price
- In our studies where piped gas was not available, it was not feasible to go off-grid with only PV and battery storage
- Implementing a microgrid for a large industrial customer is a complex undertaking and specialists from all engineering disciplines need to form part of the implementation team.

SAIEE

THANK-YOU
QUESTIONS

Proconics

Executing projects that improve and extend the life of factories