The Ideal CHP

A Decentralized DC Microgrid based on a Full Cycle Nat Gas Engines Battery Energy Storage on a DC buss

OVERVIEW

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PRESENTED BY

BENZ AIR ENGINEERING, CO., INC.

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An Alternative to District Energy

Problems Solved

- Interconnection
  - Rule 21
  - Batteries for Energy Storage
    - No Departing Load
    - No Standby Charges
- Throttle Less Rich Burn
  - Constant efficiency regardless of output.
  - 40 to 300 to 40 kilowatt < 6 seconds
- Steam instead of Useless Hot Water
  - Heating
  - Cooling
- Emissions
  - Less than 12 ppm

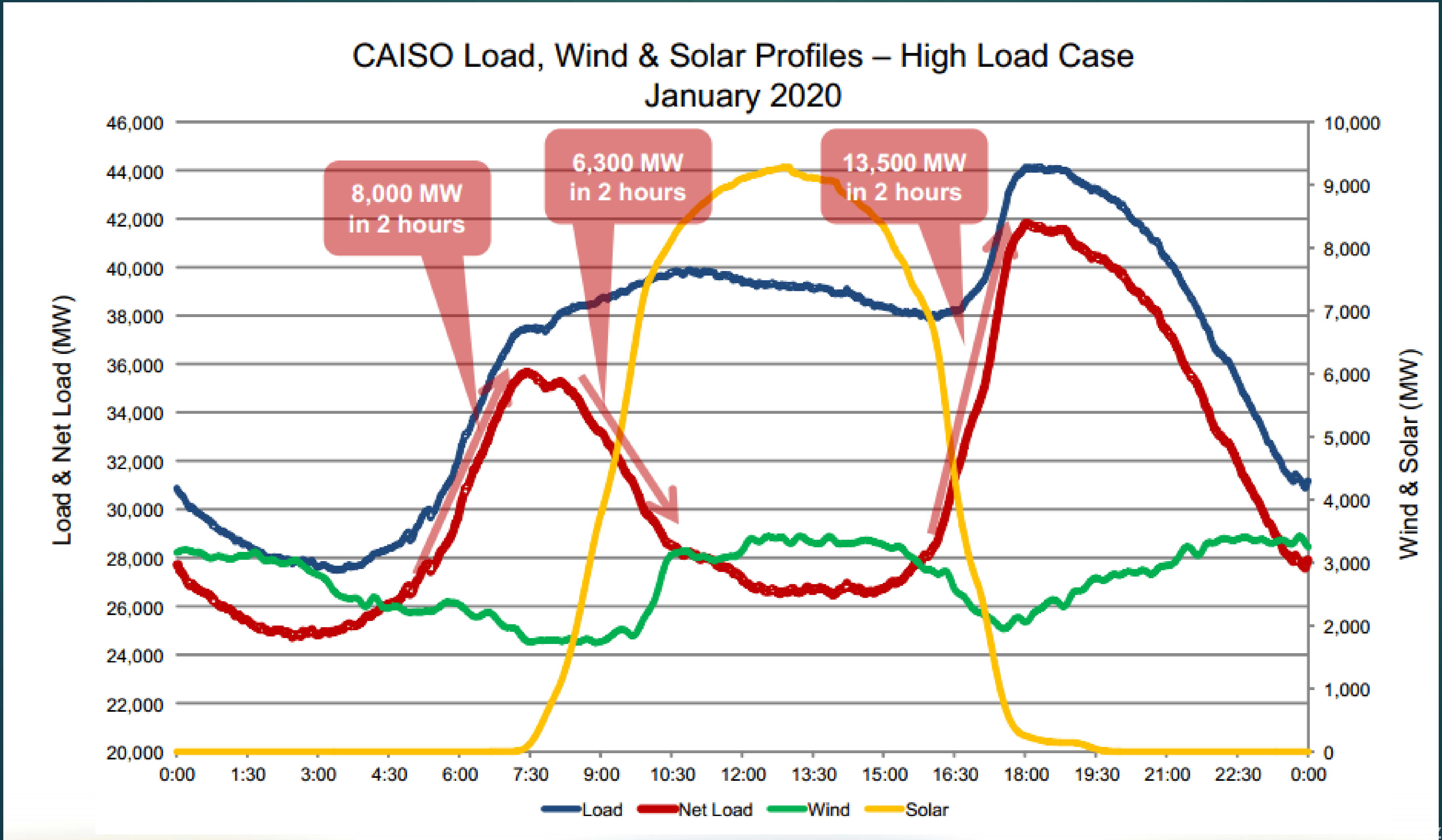
Combined Heat Cooling and Power

Battery Energy Storage
Without Interconnect Fees
No Standby Charges

Things have Changed

- Costs of Energy
  - Natural gas <=$2/mmbtu
  - Wholesale Market electricity < $30/mw-hr
- Renewable Generation
  - Power could go less than zero/mw-hr
  - Energy Storage
  - Edison is better than Tesla
    - The DC buss
  - Power is not generated when its needed.
- Heat sinks stink
  - Cant use hot water
  - Isothermal versus sensible
- Lower Emissions Required - < 10ppm Nox
- District Energy cannot Compete

Electrical Havoc on California's Grid.



Ebullient Engine Technology

Air Engineering

Energy Storage

- Thermal Energy Storage
  - Ice, hot or cold water
- Electric Energy Storage
  - Batteries
    - In and out inefficiencies.
  - Pumped Hydro
    - in and out inefficiencies
    - Only so many high altitude lakes
  - Compressed Air
    - Inefficient
    - Not as developed

Natural Gas

The Best Battery

The Ideal Solution for Low Gas $ & High Renewable

- Full Cycle Engine – Throttleless
  - Constant heat rate regardless of output
  - Instantaneous Load Control
    - 40 to 300kw to 40 < 6 seconds
  - Ebullient Cooled – 240F in 250F steam out
  - Stoichiometric – exhaust is the perfect burner
  - 3-way catalyst < 3ppm Nox
- Cheap CoGen
  - Low Penalty when not running
  - Double up the generation – No Utility Standby Charges and long life
- The DC bus
    - 700 to 825vdc
    - DC bus Microgrid
- Battery Energy Storage
  - Cheap and Available Lead Acid
  - Slow the discharge rate by "borrowing " CHP output

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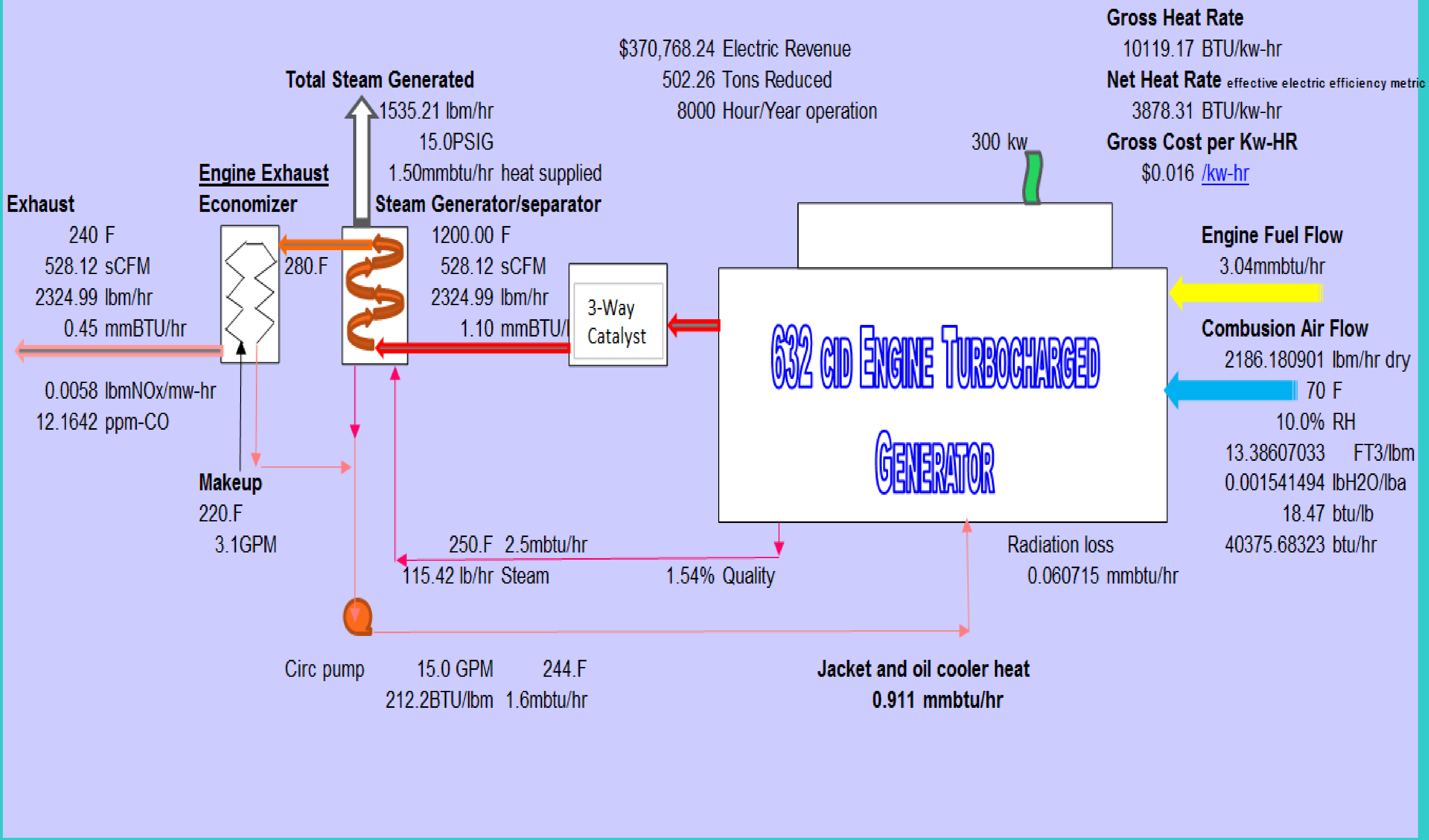
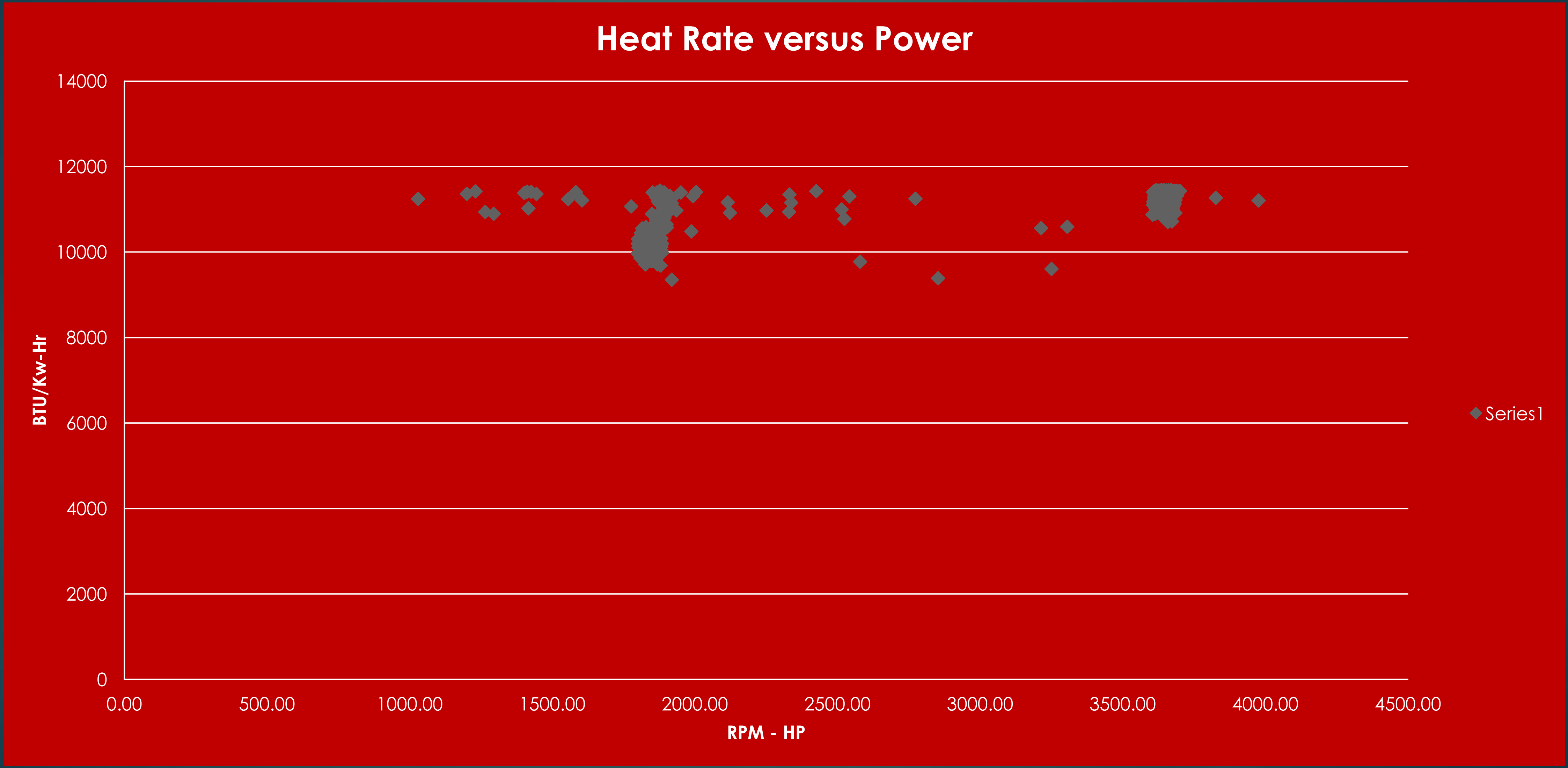
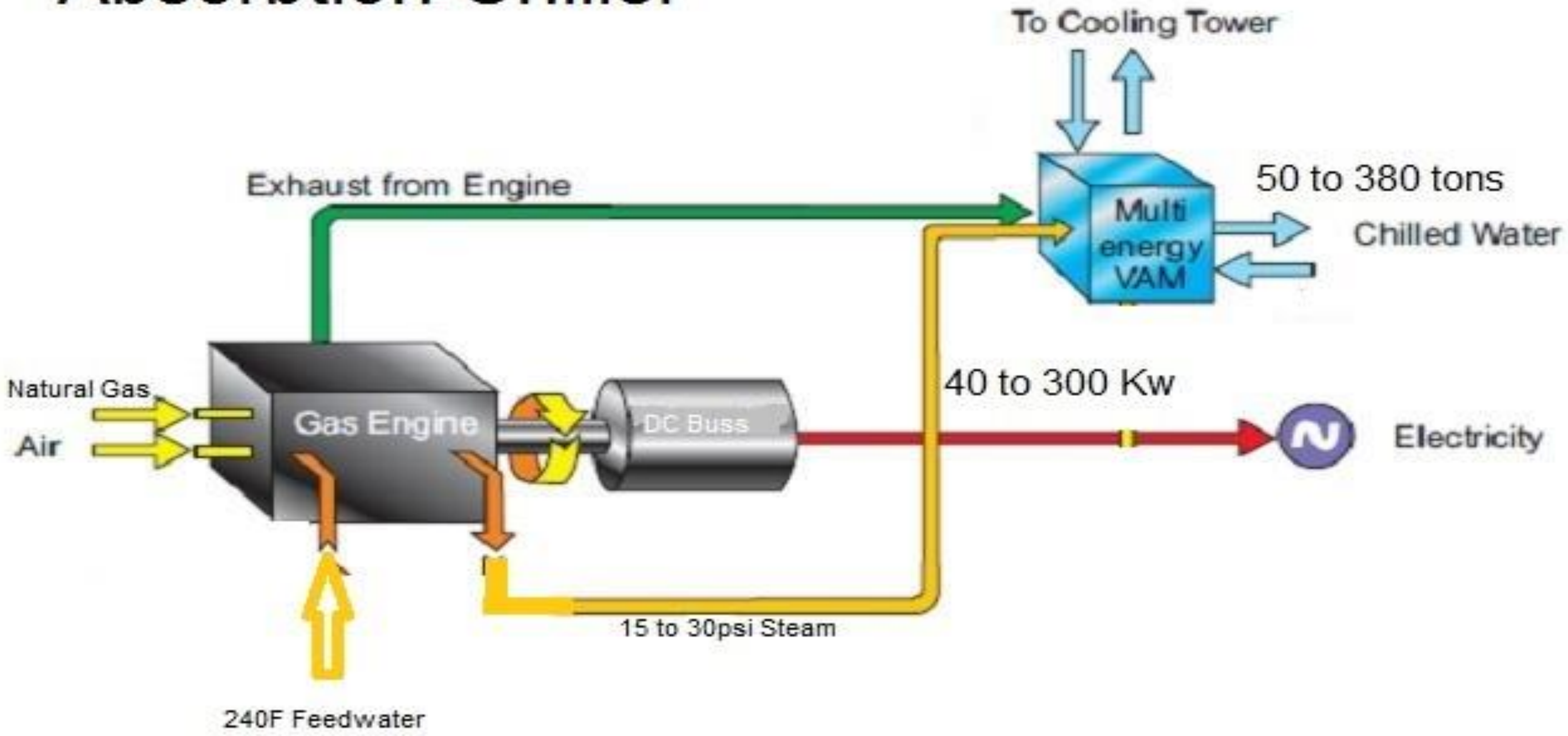
Standalone Ebullient Engine CHP



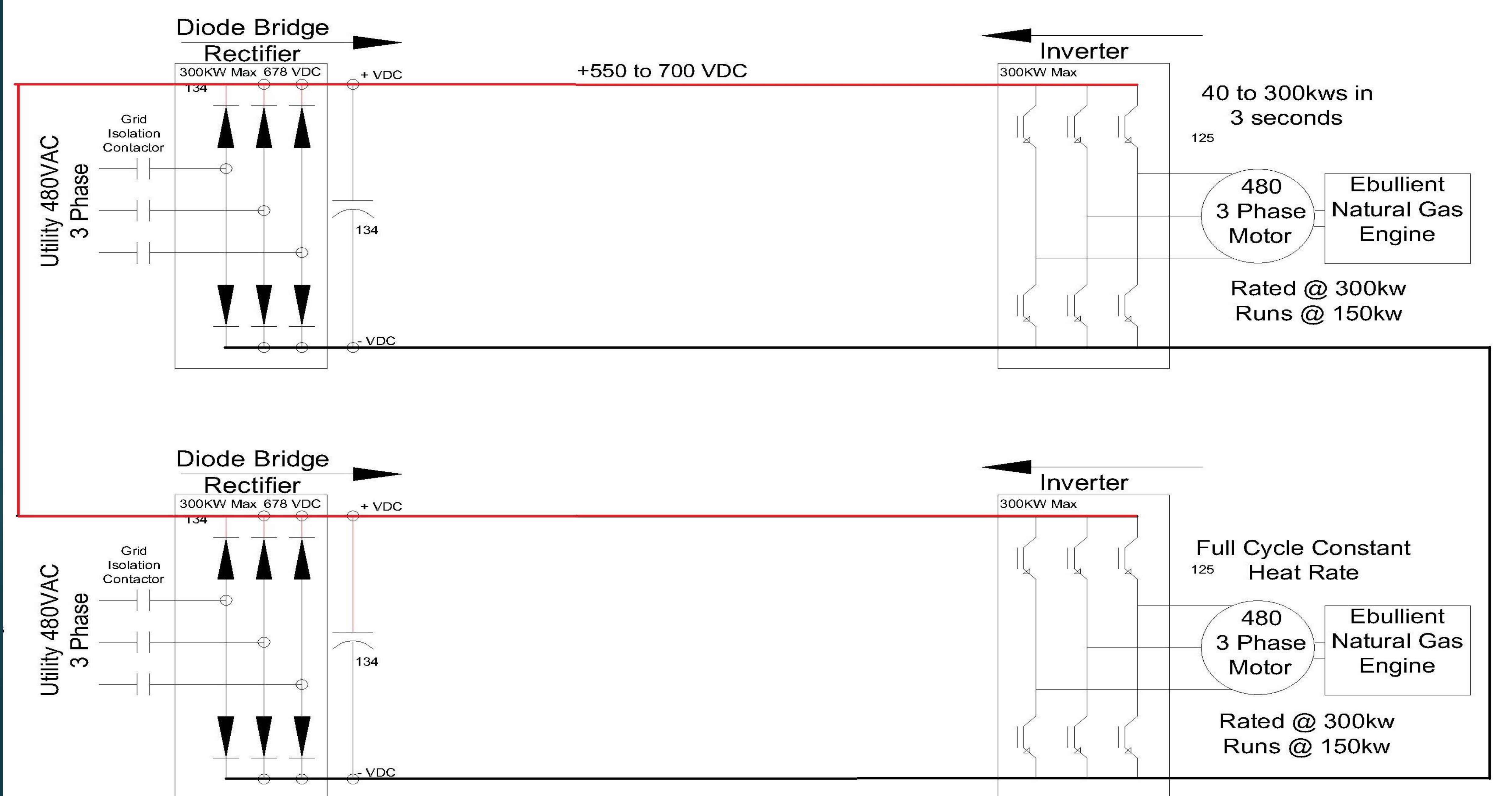
Throttle-Less Engine for Constantly Low Heat Rate Full Cycle



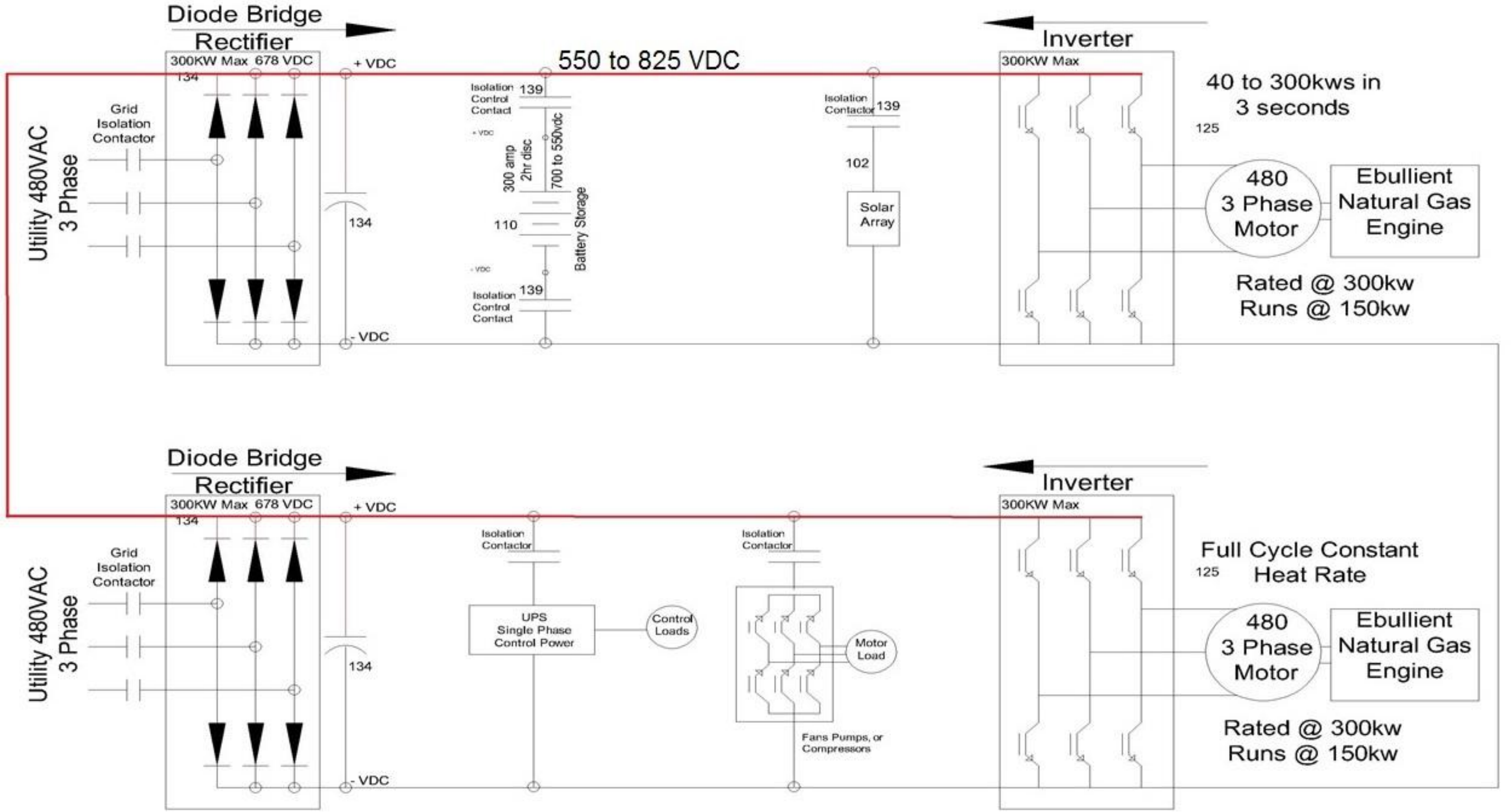
Steam & Direct Exhaust Absorbtion Chiller



The DC Microgrid



DC Microgrid



No Stand-by Charges

- SCE 6cents/kw-hr, ConEd 11cents/kw-hr
- Redundant Design for 300kw CHP will result in $144k/year savings
- Constant Heat Rate – No Energy Penalty
- Longer Life Span
- Automotive Big Block and Induction Motor/Generator

No Rule 21 Interconnect Headaches

- Design DC microgrid for one-way support from the Grid
- Diode Bridges (VFDs),
- No Rule 21 requirements

Energy Storage

- Large Incentives
  - California $1350/kw-hr
  - New York $2100/kw-hr
- Existing DC bus – might as well use it.
- Dirt Cheap Lead Acid for less than $200/kw-hr

Isolate Loads from Grid Interruption

- DC Microgrid supported by Engine HRSG Always Up
- Draw Grid power when its cheap and generate when expensive

Contact Information

Robert Benz 209-602-1019
Robert@benzair.com

Benz Air Engineering, Co., Inc.
4061 Silvestri Lane, Bldg. 103
Las Vegas, NV 89120

702-597-4805

www.benzair.com

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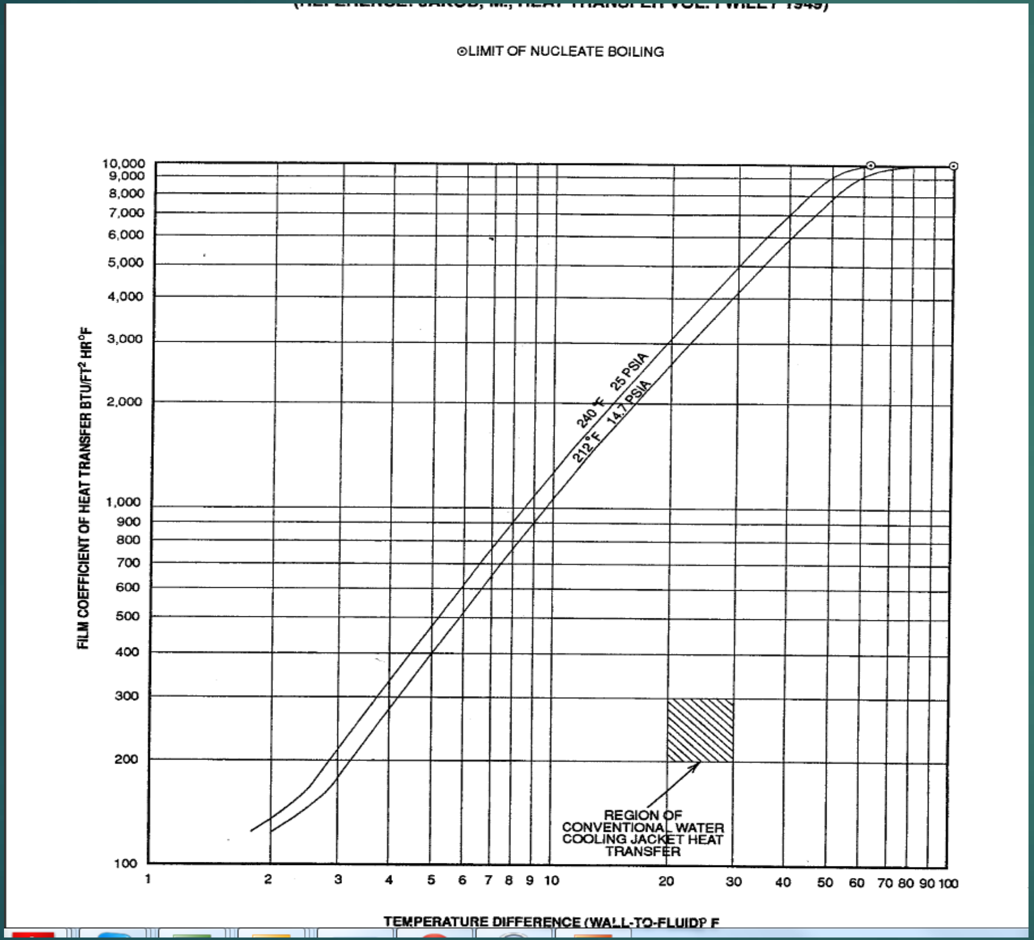
APPENDIX A. REFERENCE TECHNOLOGIES

- Nucleate Boiling Heat Transfer
- Nucleate Heat Transfer Film Coefficient
- Ebullient Cooling Flow Patterns
- Engine Absorption Cooling Example

Nucleate Boiling Heat Transfer 'Nucleate Cooling'

- 25 times the heat transfer rate of water convection
- Cooler Metal Temperatures with Hotter H20
- Uniform Head and Block Temperatures
- High Value Steam
- Low Parasitic Power – 1/10th Coolant Flow of Typical Engine
- Fast Starting
- Higher Margin in Cooling Capacity
  - Typical engine cooling is limited to 180F outlet water.
  - Constant temperature of Nucleate Cooling lacks any Limitation.

Nucleate Heat Transfer Film Coefficient



- Note tremendous difference in heat transfer rate for a given temperature difference between metal and coolant.
- That difference needs to be minimized for durability. – thermal stresses.

Engine Absorption Cooling Example