

Saving Fuel Using a Stirling Engine

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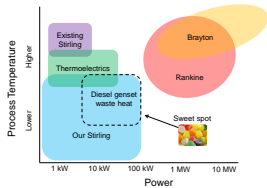
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Introduction and Overview



Exciting Market Opportunity

Technology and Innovation

Unique Market Positioning

Path to Market

Diesel Generation is a Big Problem

5%

world energy production – **1,000 GWh**

95%

off-grid power generation – **30 GW**



Extremely High Diesel Costs for Military

Fully burdened cost
of diesel, forward
deployed bases



Ratio of per capita
fuel use, US military
vs. civilian:

\$100 / L

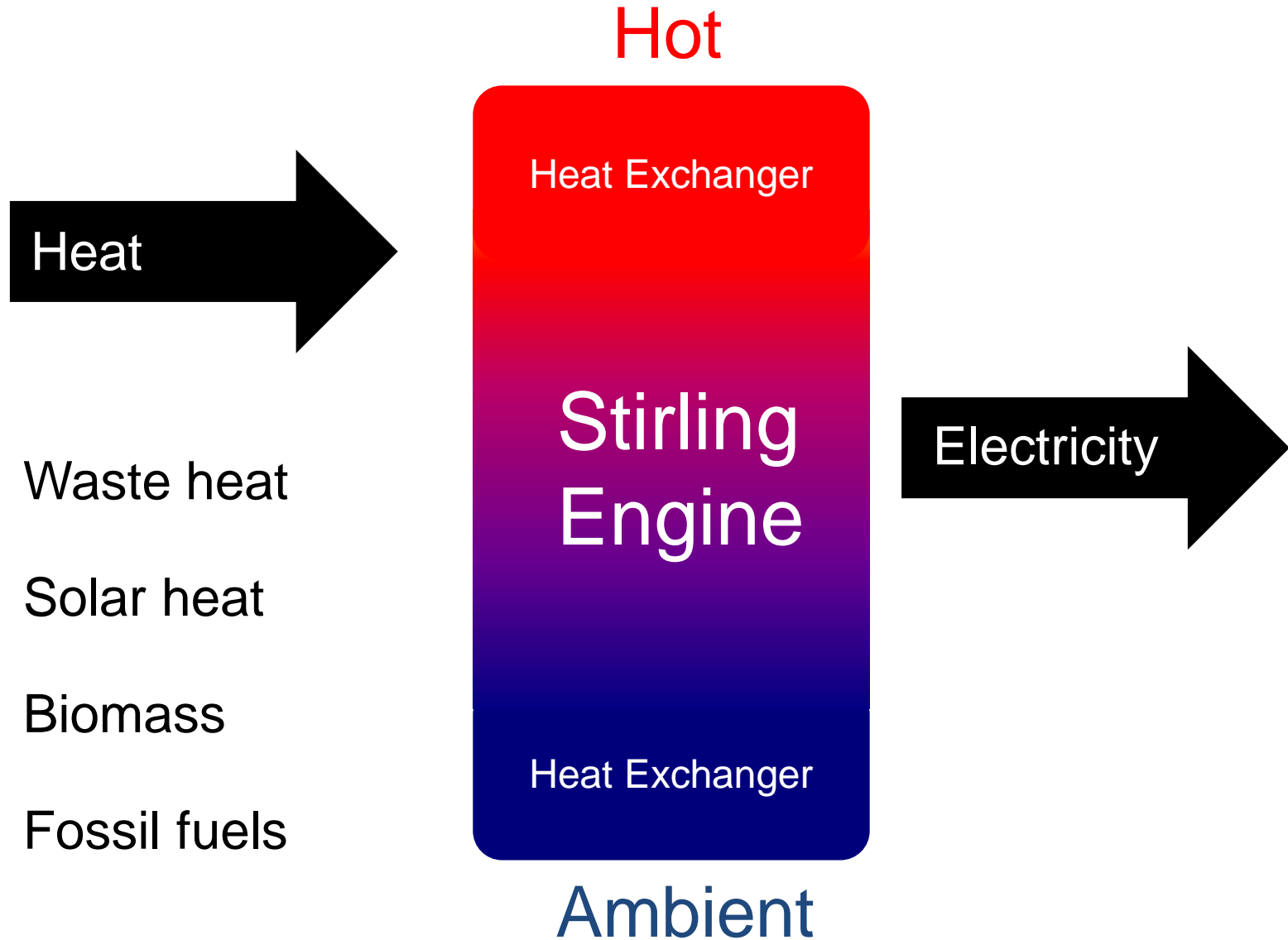
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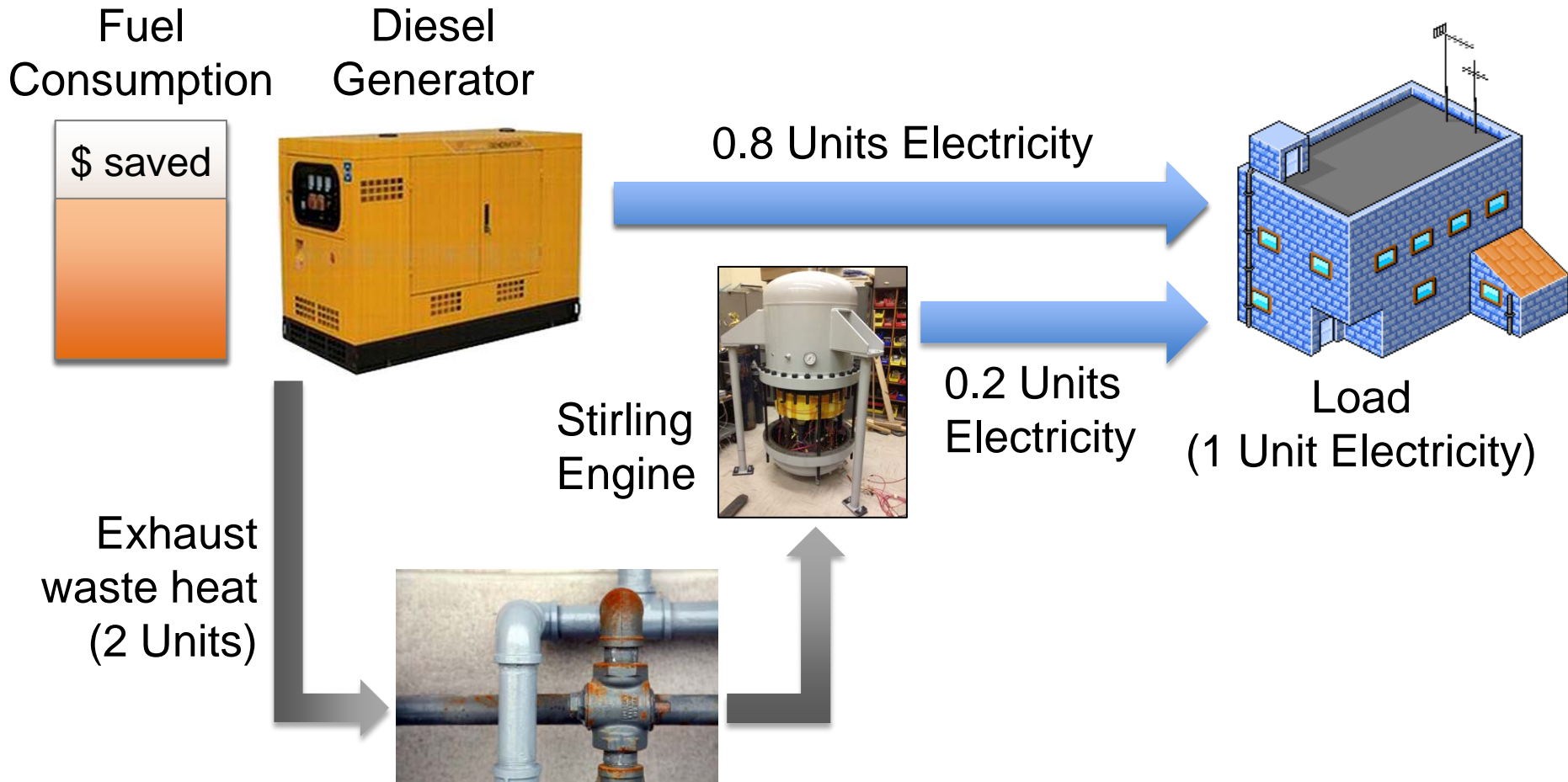
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**Soldiers Killed or Wounded in Iraq Between
2003-2007 Were Protecting Fuel Convoys**

Stirling Engine 101



Diesel Genset Augmentation is a Clear Application



Drop-in technology for improving diesel efficiency with a short pay-back period

Technology Advantages and Disadvantages

Advantage

- Flexible fuel: only requires heat
- Theoretically more efficient



Disadvantage

- Other cycles are cheaper at larger sizes
- Expensive heat exchangers required
- Poor reliability



Our Tech

Best of Stirlings

- Flexible fuel intake
- High efficiency

Reduced Disadvantages

- Designed for low cost
- Highly efficient, low-cost heat exchanger
- Increased reliability

Innovative Ultra-efficient Heat Exchanger



Ultra-efficient heat exchanger



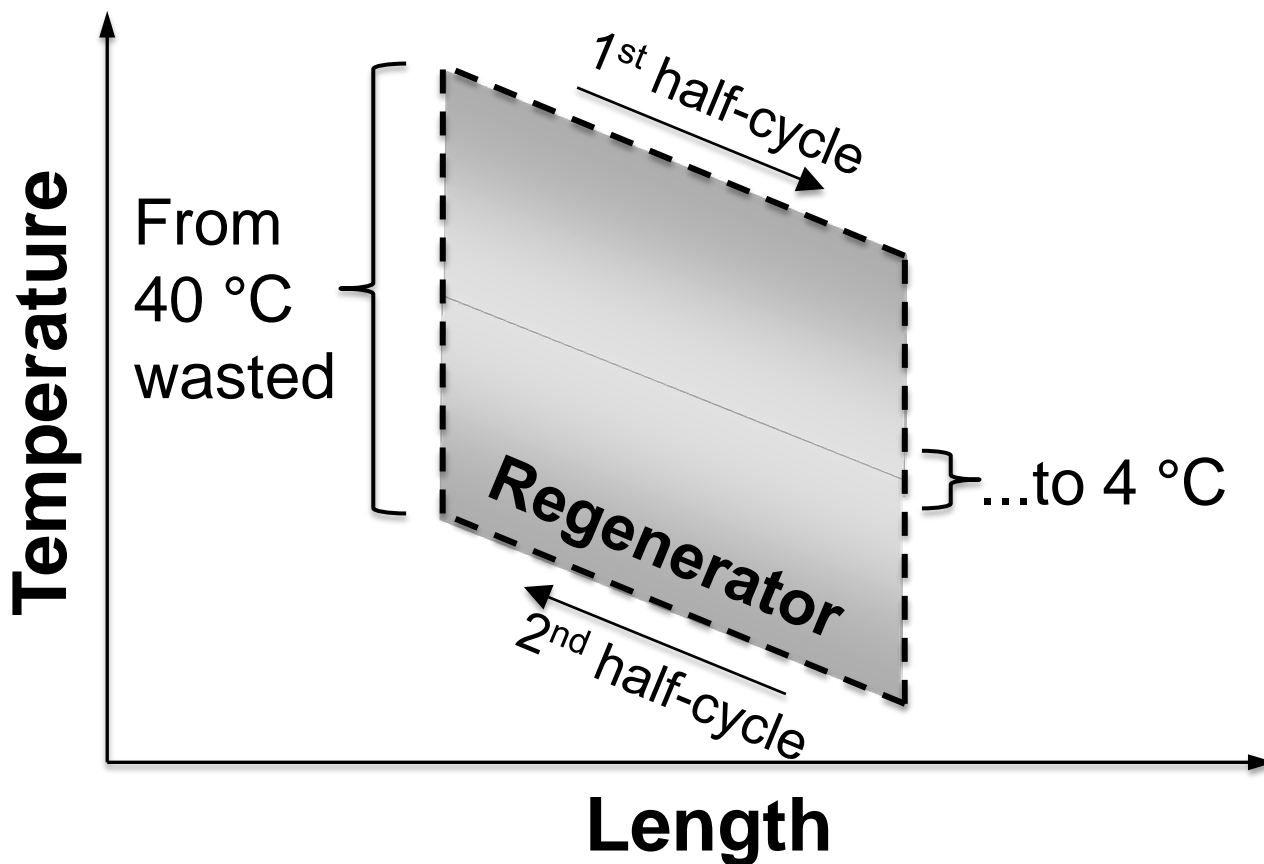
Order-of-magnitude less temperature loss



Less heat wasted



Higher Efficiency



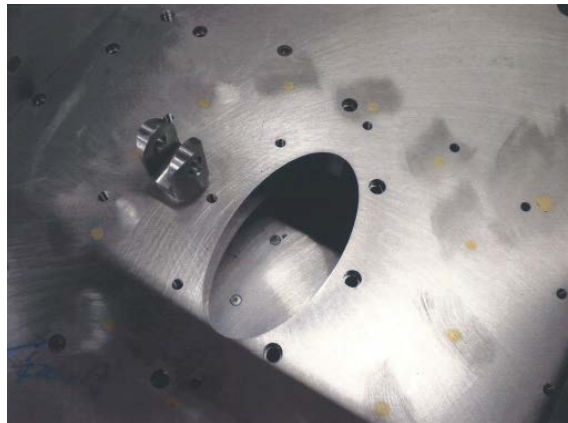
Low-Cost Advantages

Materials

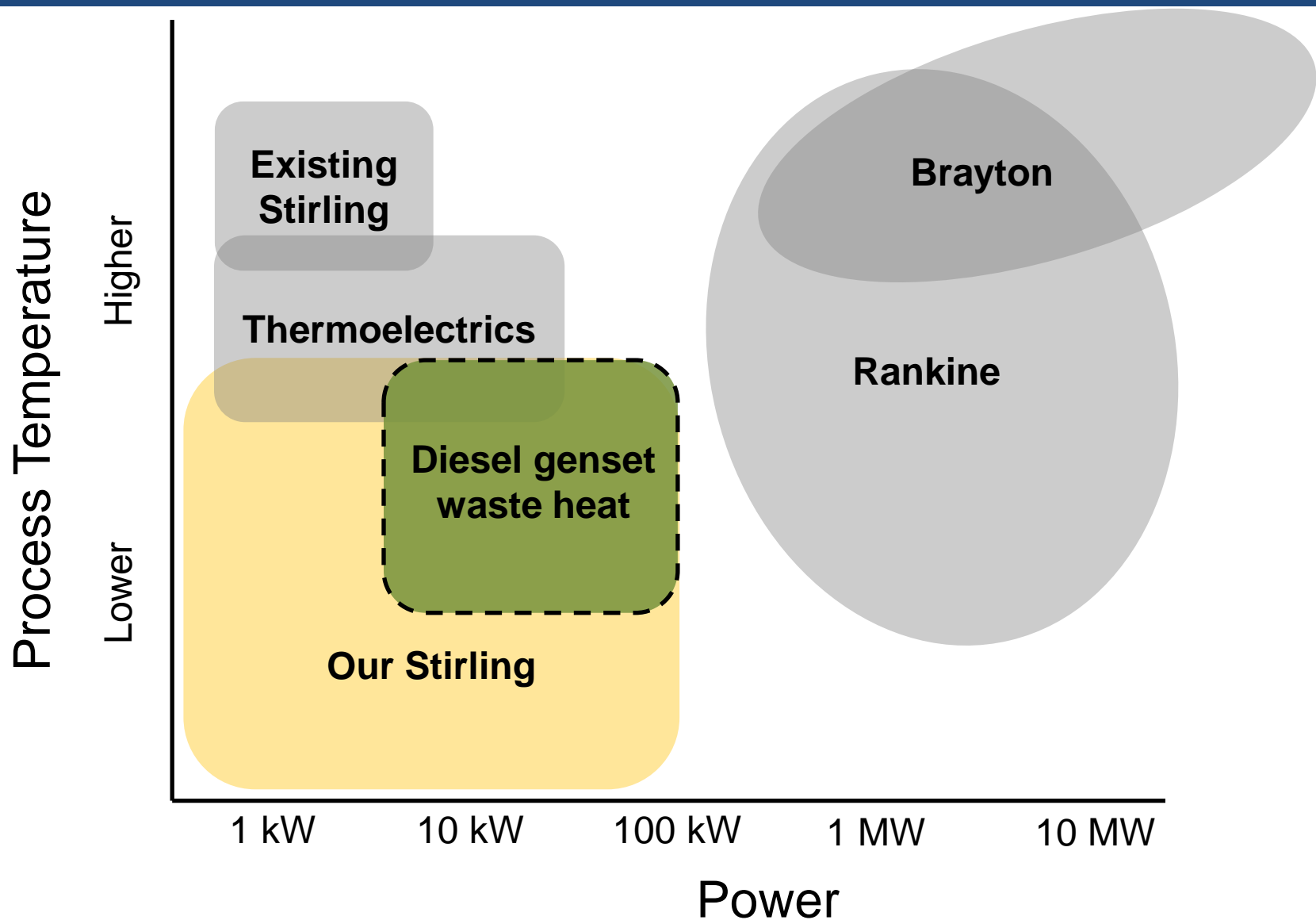
- Primarily off-the-shelf components
- Low-cost heat exchanger

Manufacturing

- Simple design limits fabrication complexity
- Very few parts require machining



Filling a Gap Versus the Competition



Ideal Use Case: Increasing Diesel Genset Efficiency

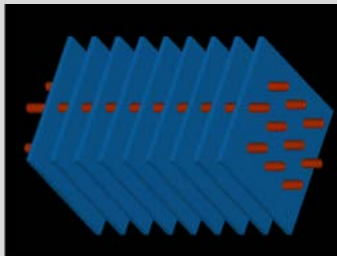
**Optimized for Diesel's
Power Range**



**Efficiency and Cost
Advantage**



**Technology Complements
Heat Source**

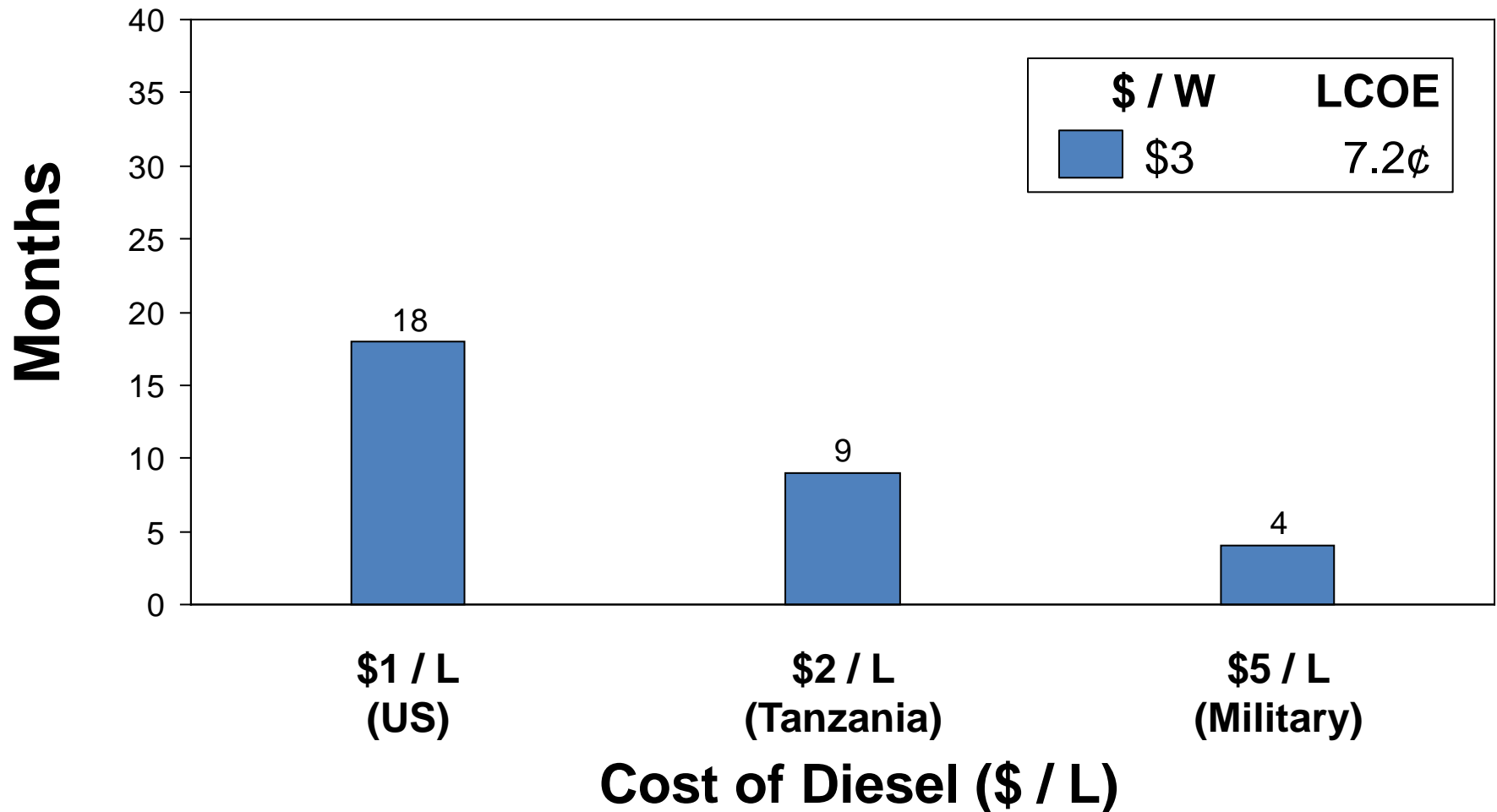


**Medium Temp. Means
Higher Reliability**



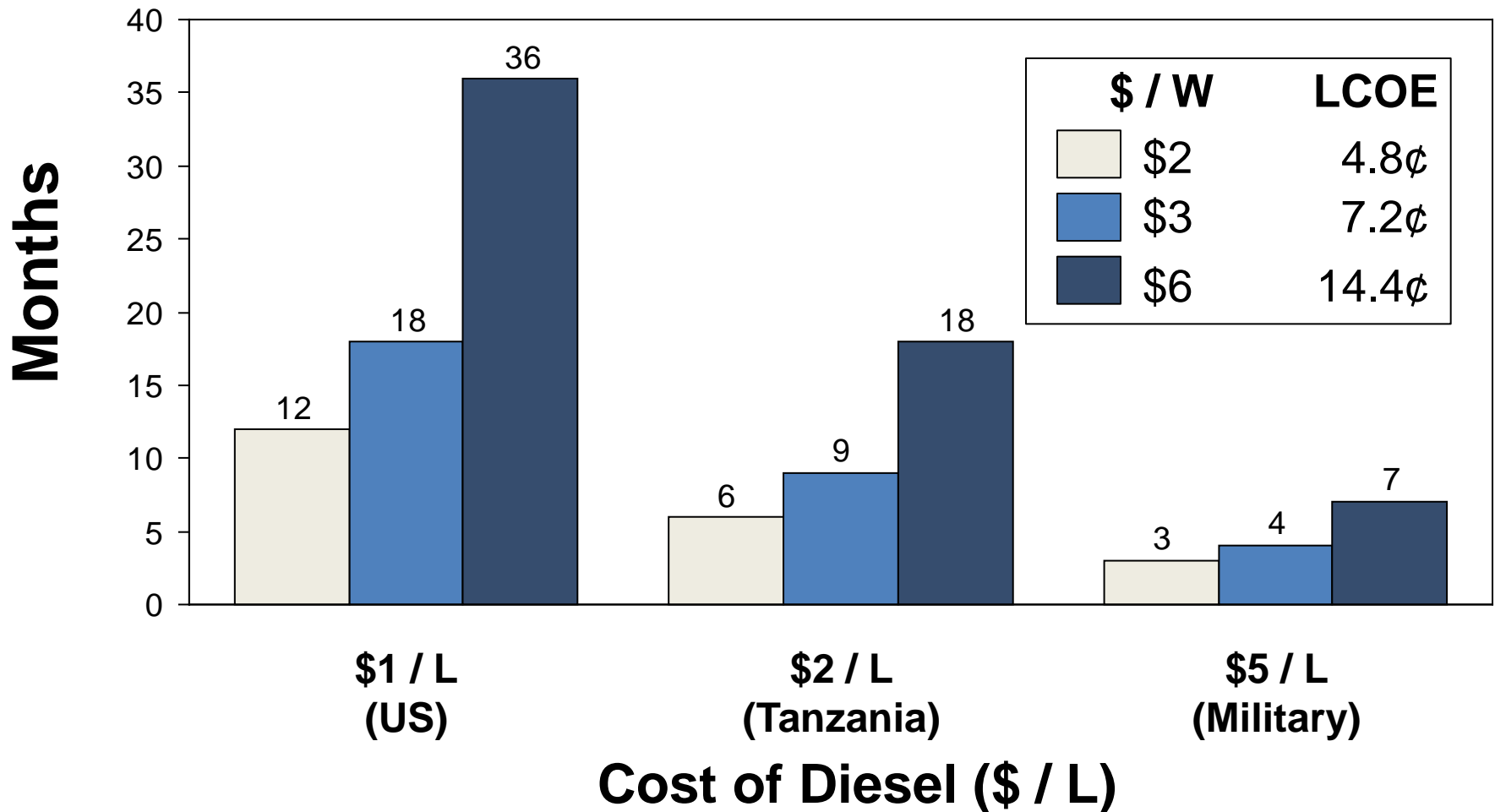
Efficiency Yields Payback under 2 Years in Base Case

Simple Payback Period in Months by Cost of Device and Cost of Diesel

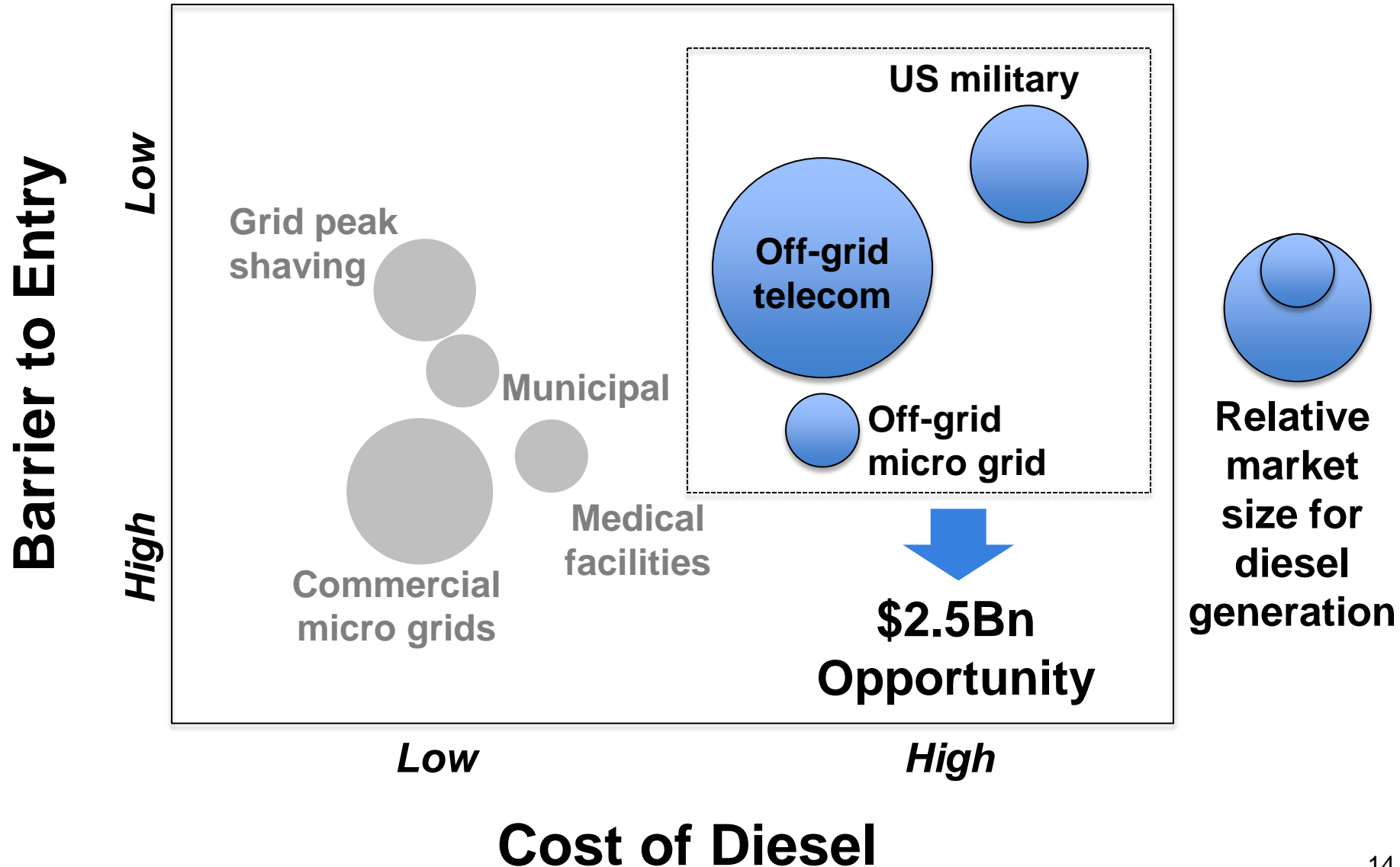


Efficiency Yields Payback under 2 Years in Base Case

Simple Payback Period in Months by Cost of Device and Cost of Diesel



Prioritization of Diesel Generation Market Segments



Sales Channels

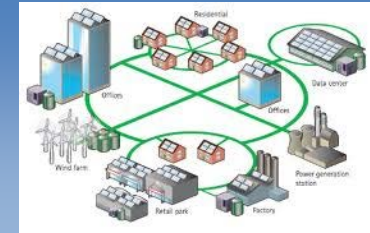
US Military
\$800M



Telecom
\$1.5Bn



Micro-grid
>\$200M



Telecoms

Manufacturers



Roadmap to Market

0-6 months

- Finalize design
- File IP



6-18 months

- Finalize prototype and test



Long-term

- Develop sales channels and manufacturing partnerships
- Reduce cost
- Revisit other applications (CHP, solar)



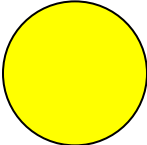
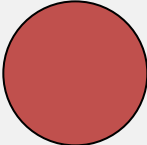
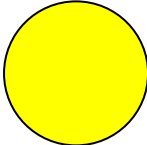



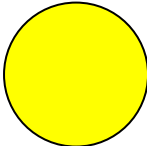
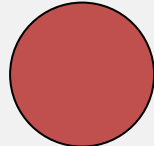

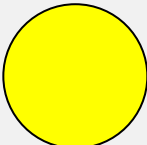
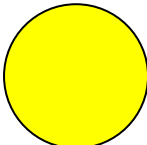




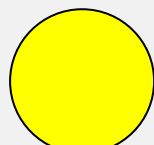
Summary







- 20% Efficiency Increase
- Payback Period Less than 2 Years
- Large potential market

Appendix Slides

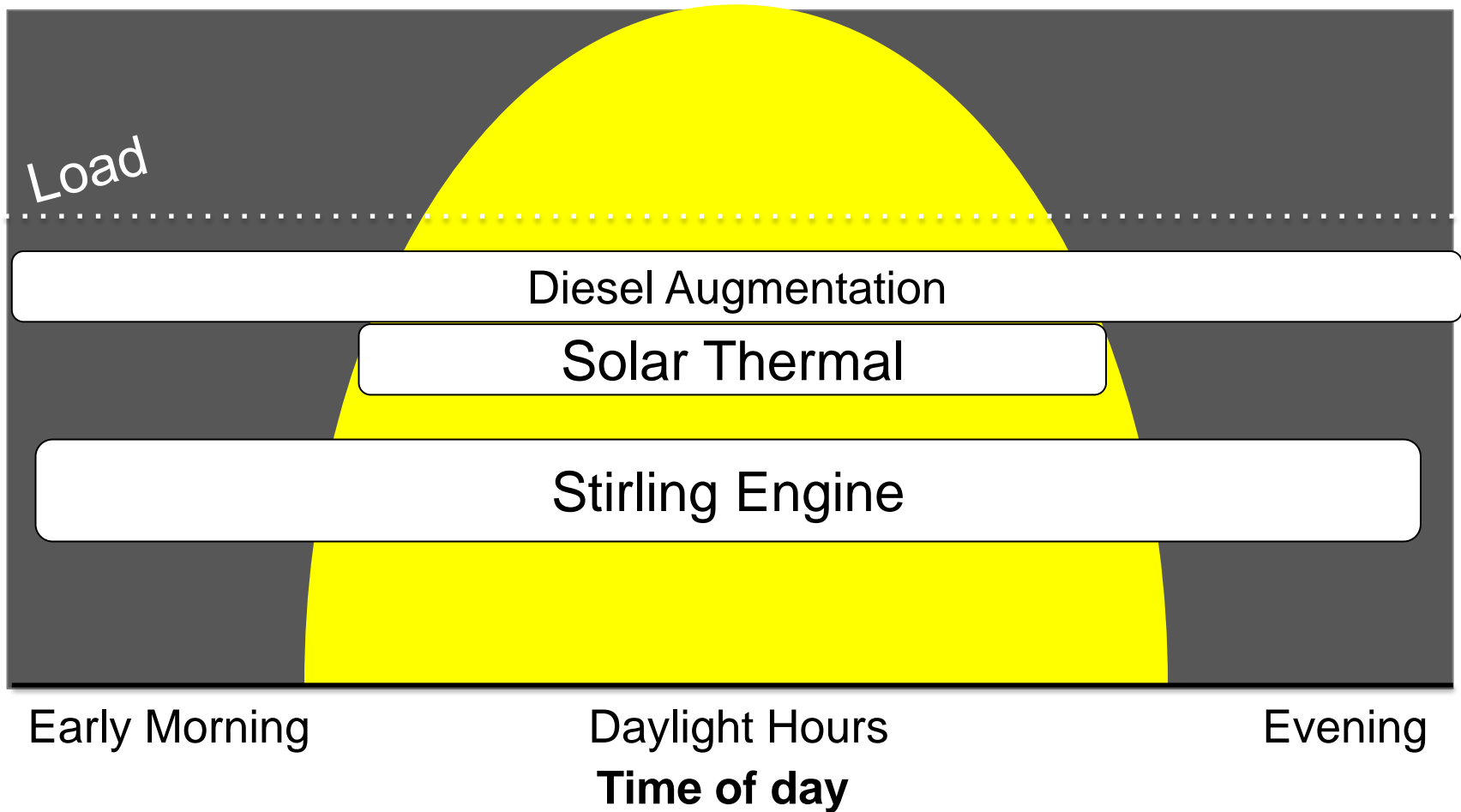
Competitive Advantage Improves On Status Quo


Customer Need	Our Technology	Other Stirling Engine	Rankine Cycle	Status Quo
Capital Costs				
Operating Costs				
Efficiency at Low Power				
Reliability				

Risks and Mitigation Tactics

	<u>Risk</u>		<u>Mitigation</u>
IP	<ul style="list-style-type: none">• Lack of IP protection relative to competition		<ul style="list-style-type: none">• File provisional patents on key innovations
Market Conservatism	<ul style="list-style-type: none">• Customers seek products with proven track record		<ul style="list-style-type: none">• Conduct initial testing with customers willing to take on risk
Cost	<ul style="list-style-type: none">• Cost not competitive relative to other technologies (e.g. PV)		<ul style="list-style-type: none">• Diesel augmentation as first market; lower cost via continued refinement
Market Trends / Competition	<ul style="list-style-type: none">• Competition will continue to improve		<ul style="list-style-type: none">• Utilize advantages of technology: flexible fuel source, storage

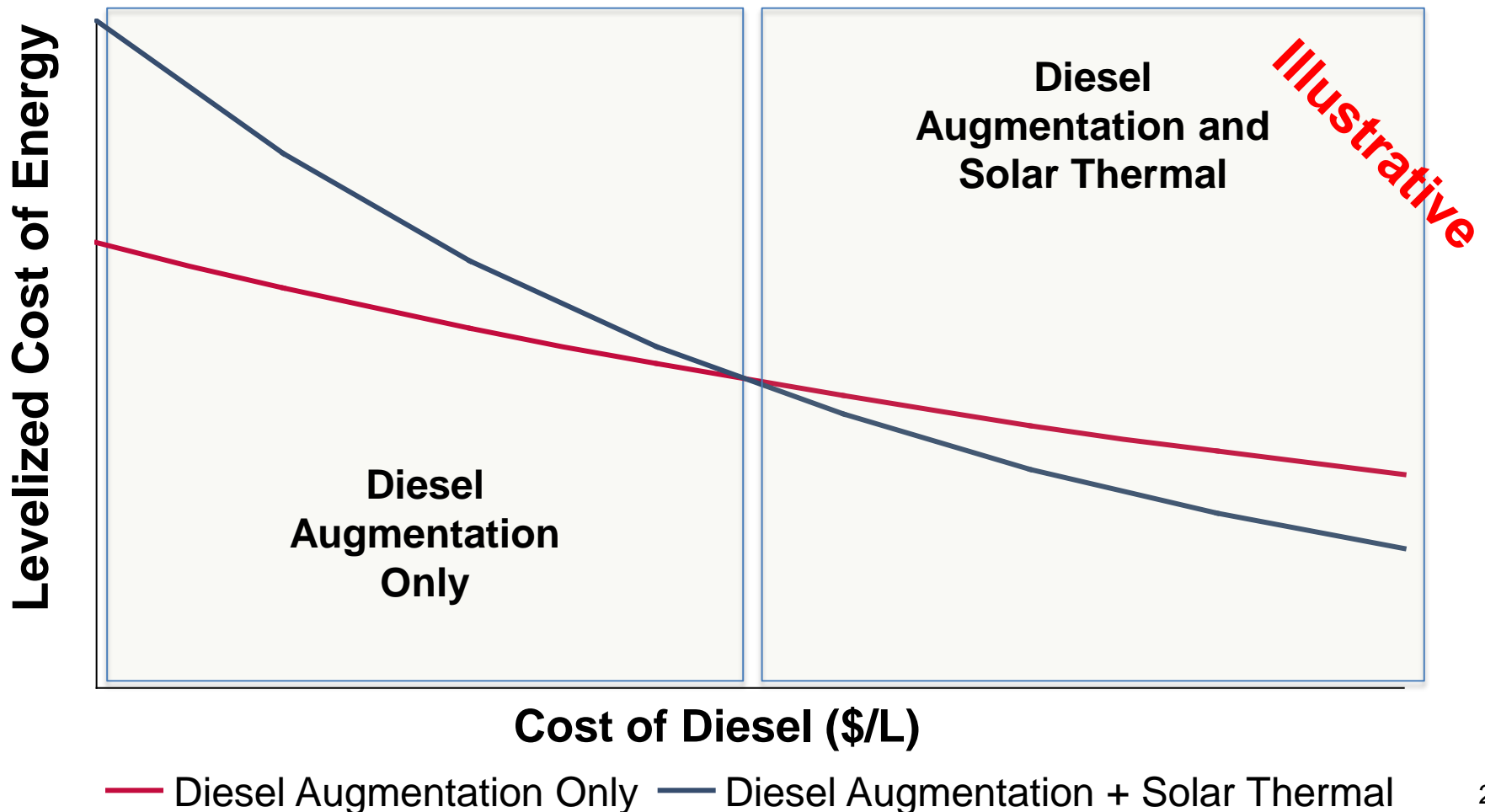
Secondary Application: Solar Thermal with Diesel Waste Heat Extraction



 *Seamless all-day solution for energy needs with even greater return in areas with expensive diesel and a good sun source*

Hypothetical LCOE by application type and cost of diesel

Combining solar thermal with diesel augmentation could make sense in locations with very high diesel cost (e.g. military)



Filtering Criteria and Narrowing of Market Applications

Technical Factors

Temperature

Required Power Output

Form Factor

Commercial Factors

Customer Use Case / Cost

Market Factors

Barriers to Entry

Household solar thermal

Re-heat cycle

Dairies / manure

Sewage treatment

Solar thermal, utility scale

Steam regeneration

Backup Generation

Triple bottoming cycle

Oil and gas extraction

Geothermal

Boiler Waste Heat

Household natural gas / CHP

Remote power / micro-grid solar thermal

Diesel Augmentation