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September 19-21, 2023 | Schaumburg, Illinois

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Sustainability:
The New Frontier for Innovation

Executive Leadership Provided By:



Cruising towards Zero

Dheeraj Gosala, Ph.D.

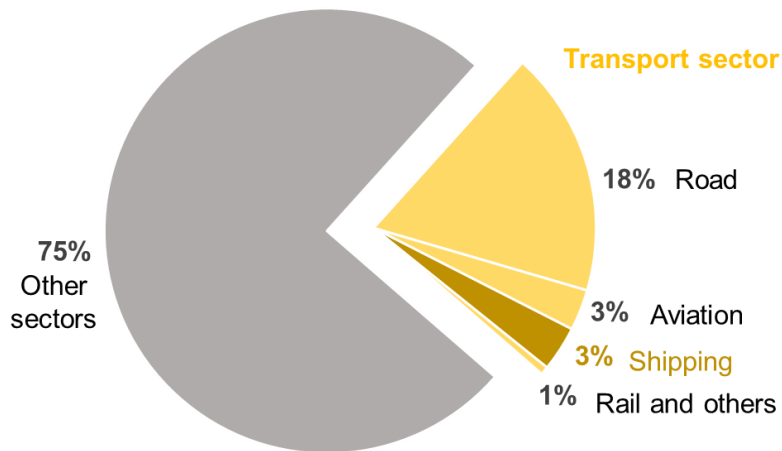
Research Scientist

DLR Institute of Maritime Energy Systems

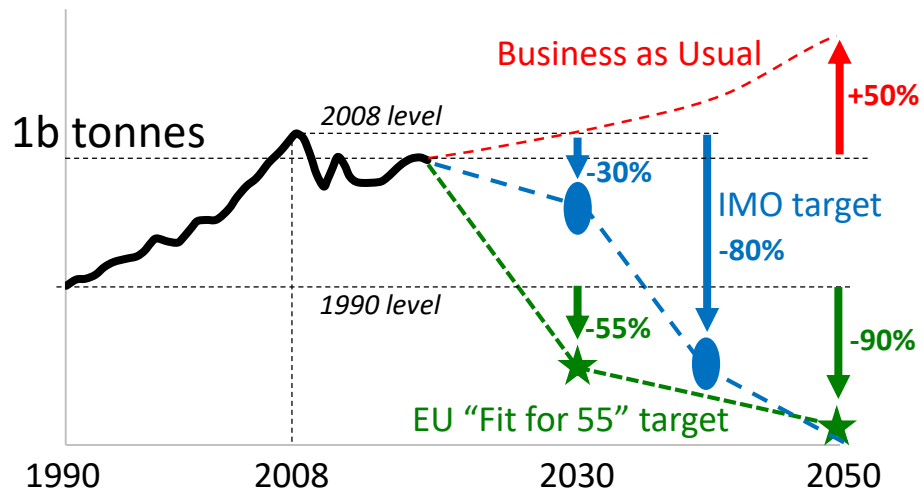


Background

Global GHG Emissions (2018)



GHG Emissions from Shipping



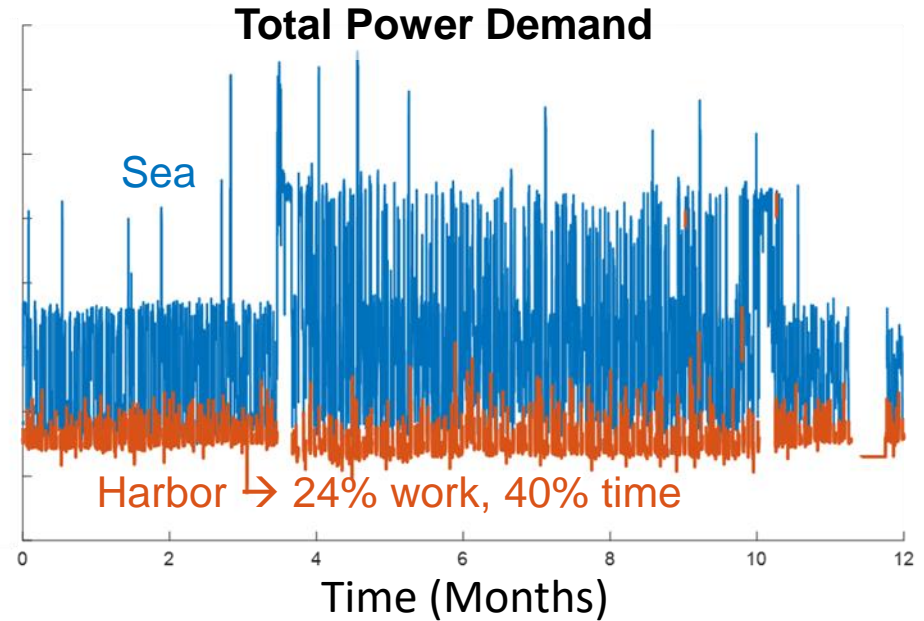
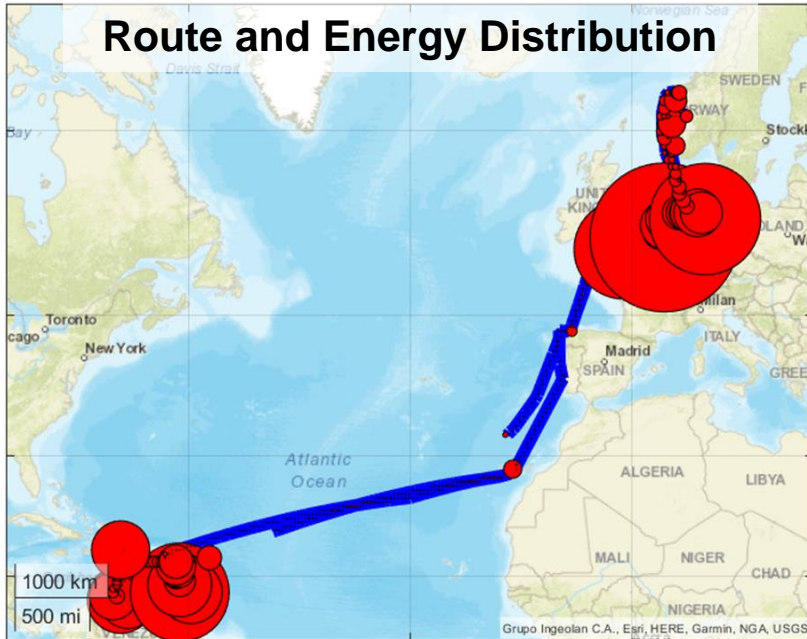
Cruise Ships

- Major contributor to global tourism
 - > \$150 billion economic activity
 - 1.2 million jobs
- Significant emissions from cruise ships
 - CO₂ ≡ 84,000 cars
 - NO_x ≡ 420,000 cars
 - PM ≡ 1.05 M cars



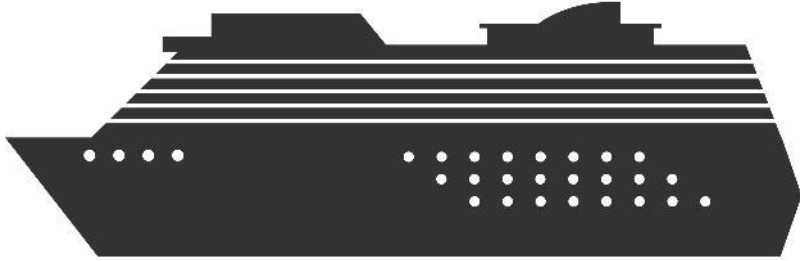
Energy efficiency & pollutant reduction of cruise ships
essential to meet sustainable development goals

Cruise Ship Operation



Pollutant-free operation in harbors and sensitive areas important

Scope

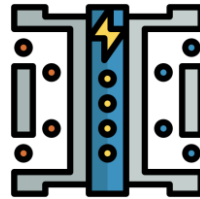


- Improve efficiency
- Reduce pollutant emissions (harbors & sensitive areas)

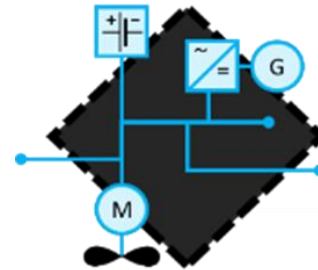
Batteries



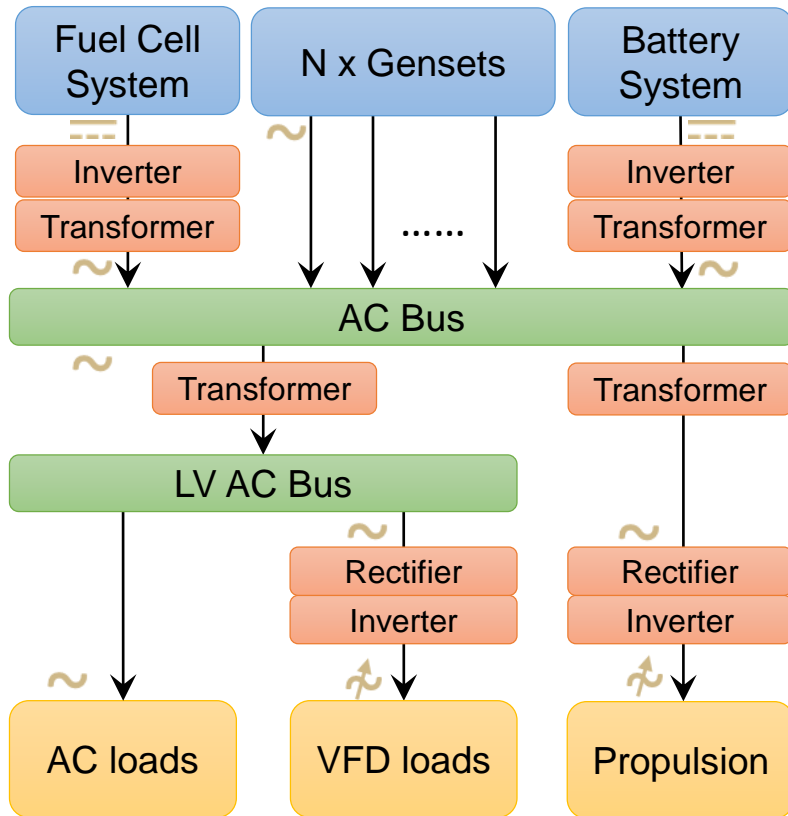
PEM Fuel Cells



DC grids



Grid Configuration in Modern Cruise Ships

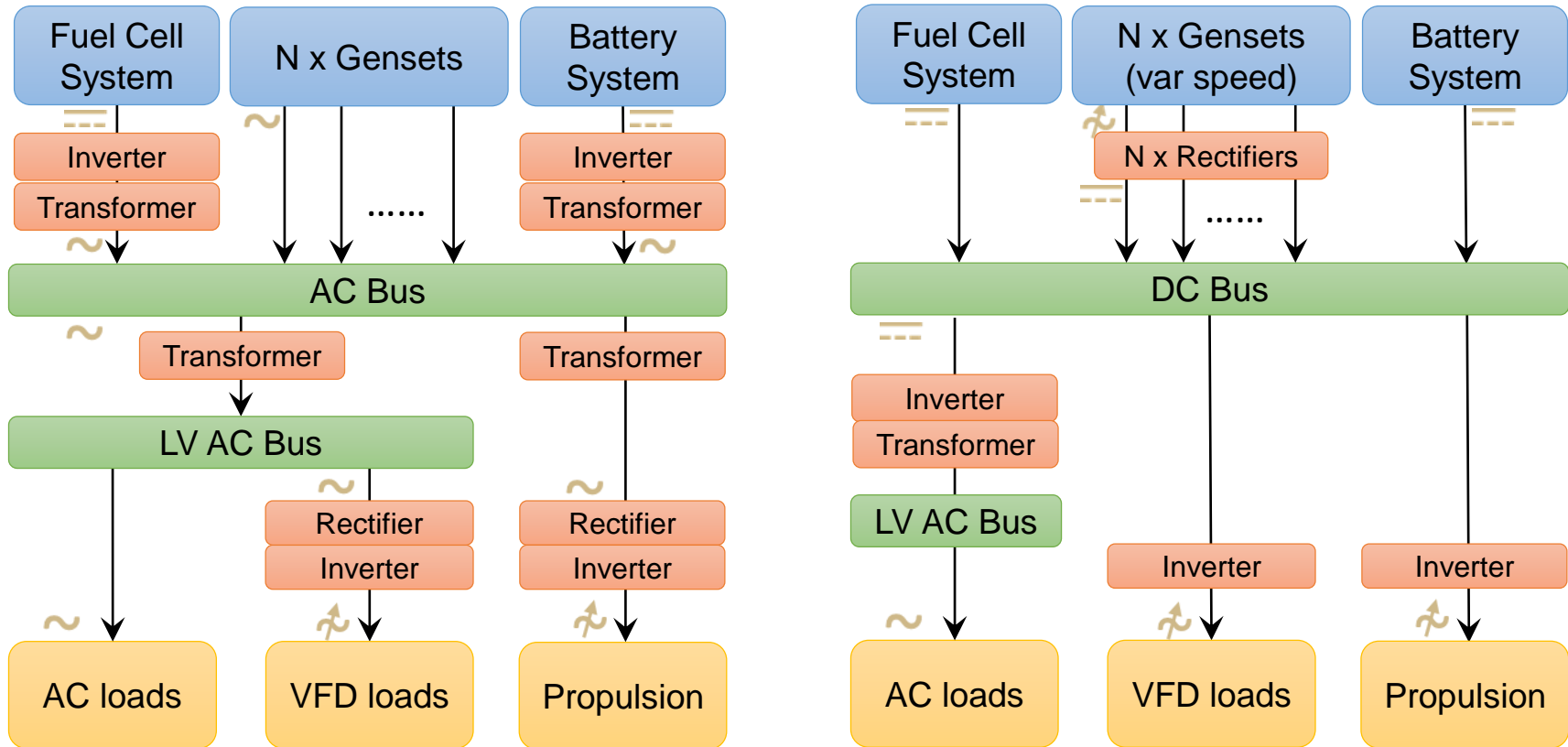


Power Generation
& Energy Storage

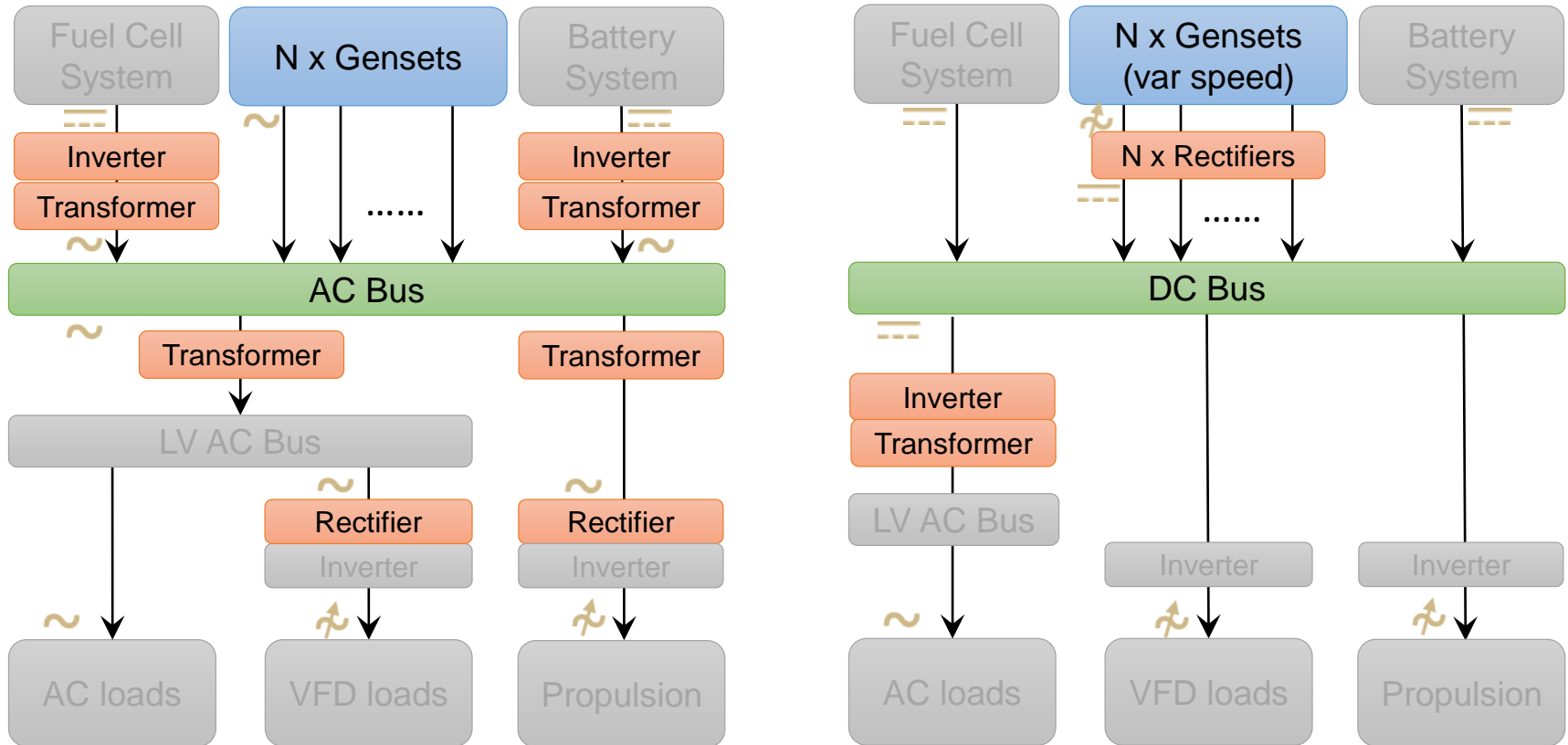
AC Power Distribution

Power Consumers

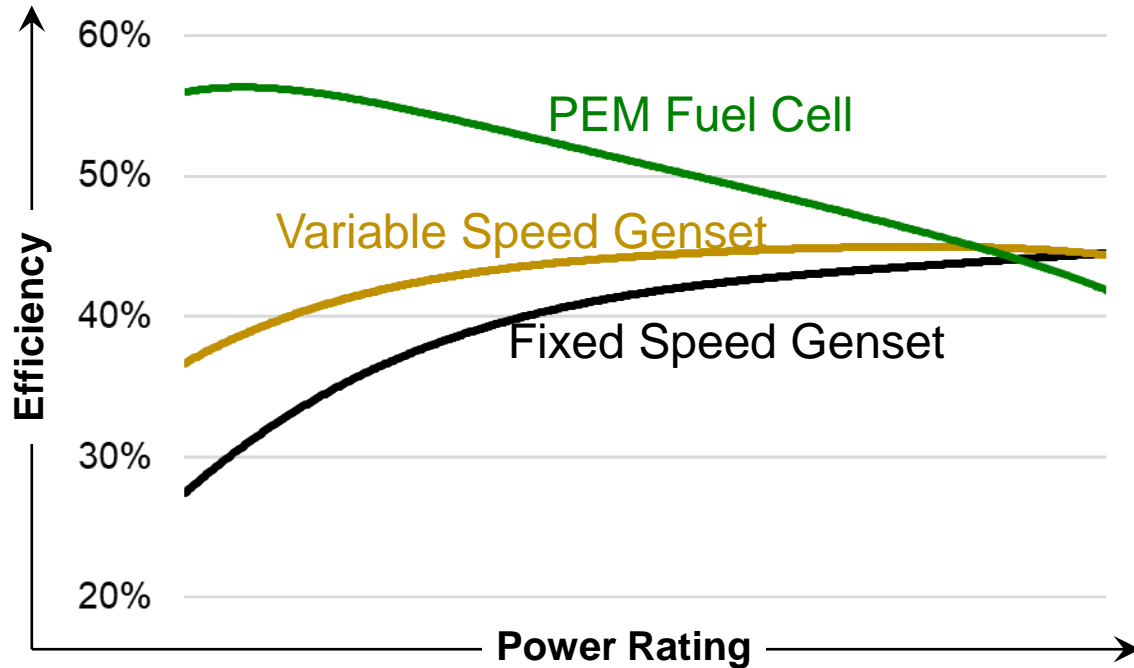
Grid Configuration in Modern Cruise Ships



Grid Configuration in Modern Cruise Ships

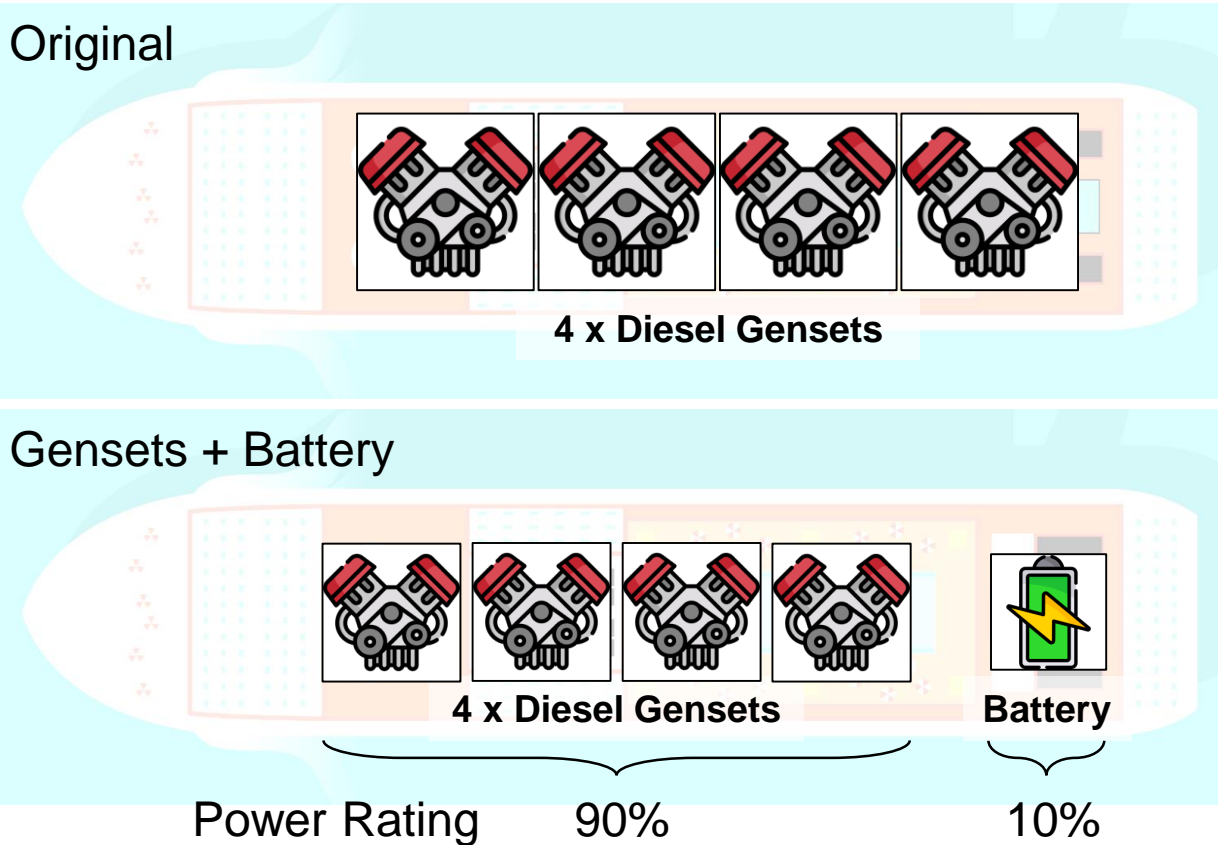


Power Generation Efficiency

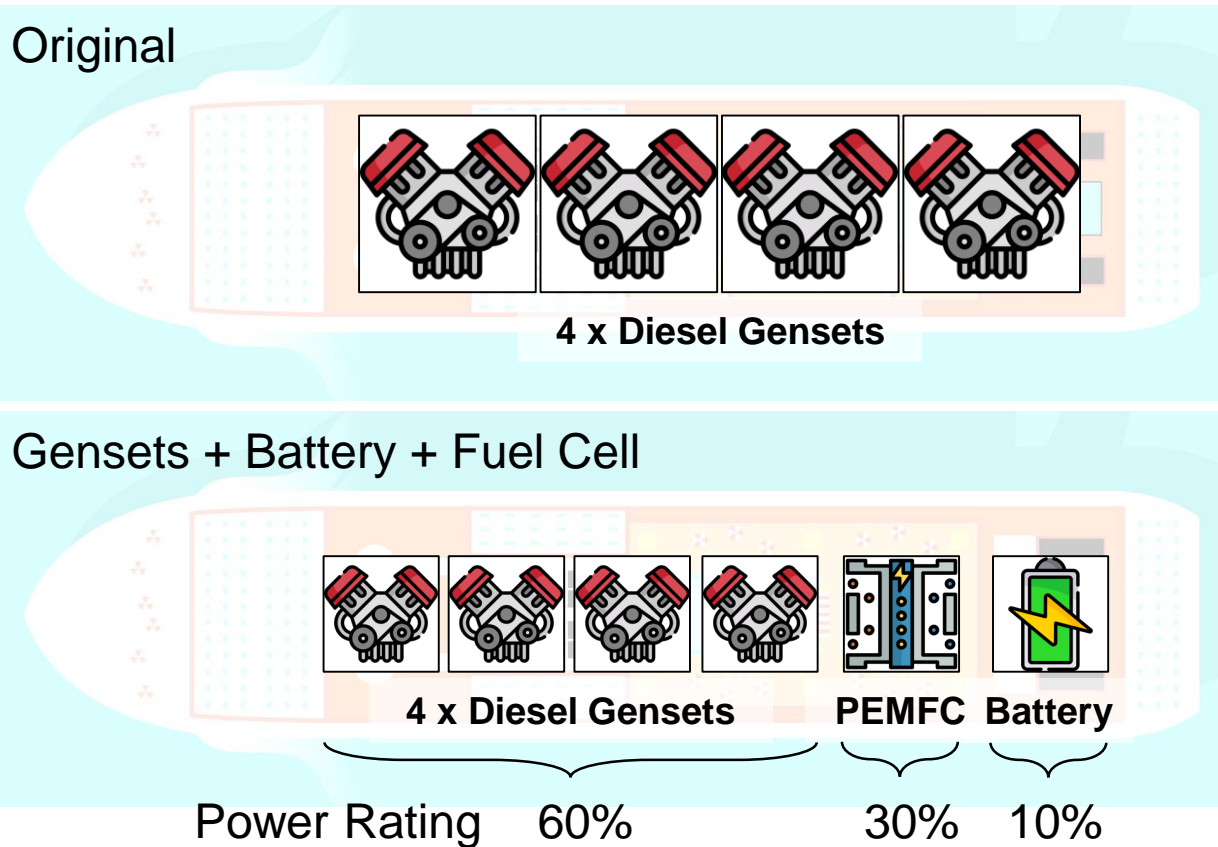


Fuel Cells & Variable Speed Gensets display higher part-load efficiencies

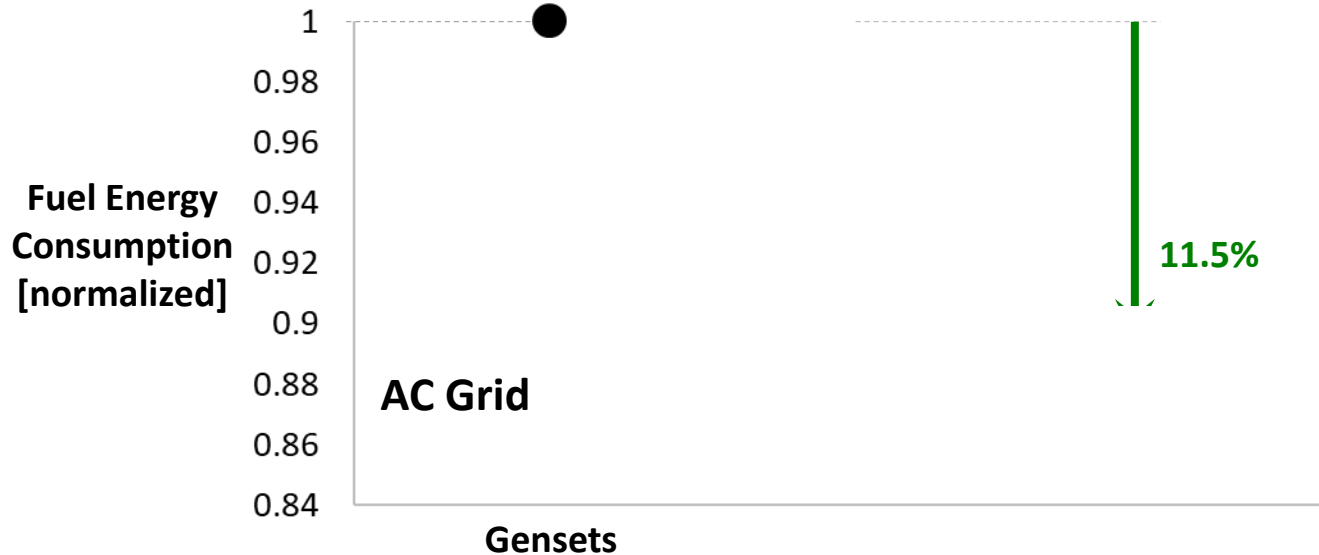
Energy System Configuration



Energy System Configuration

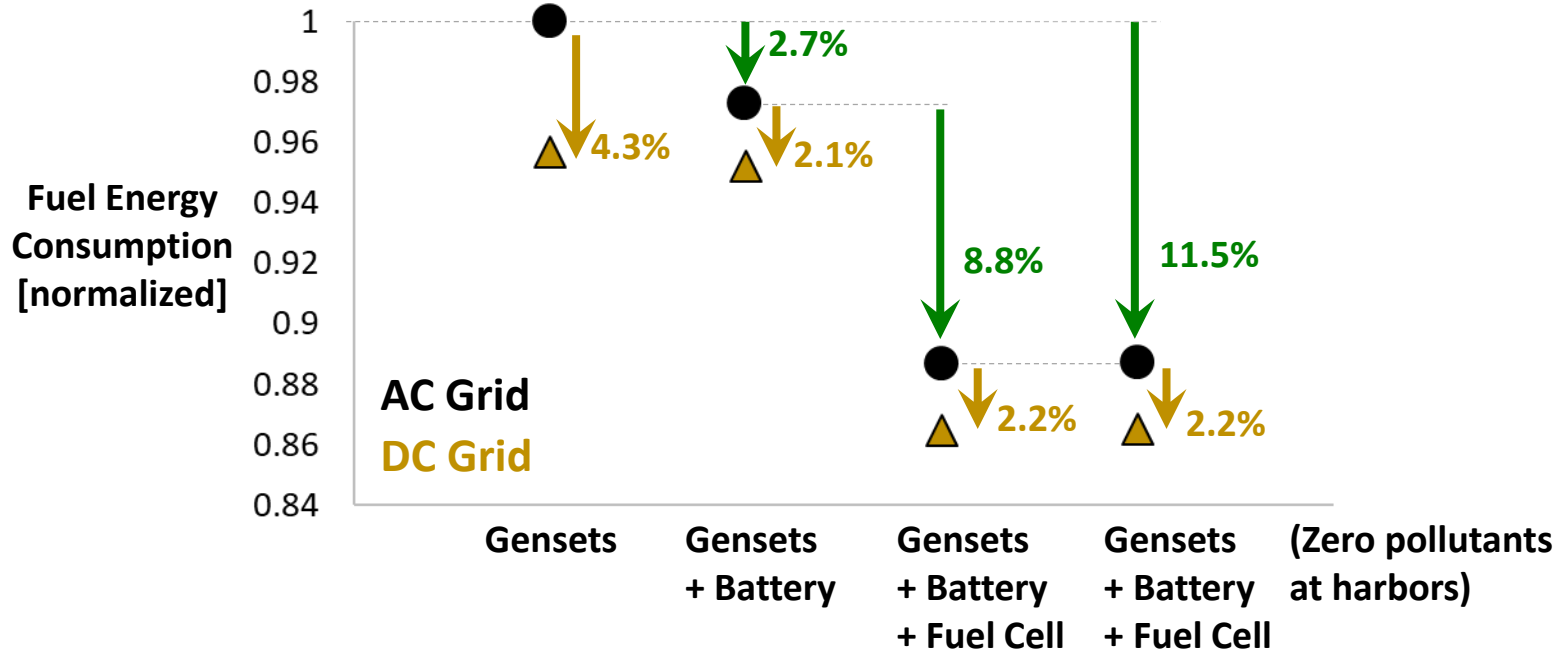


Results – Fuel Energy Consumption



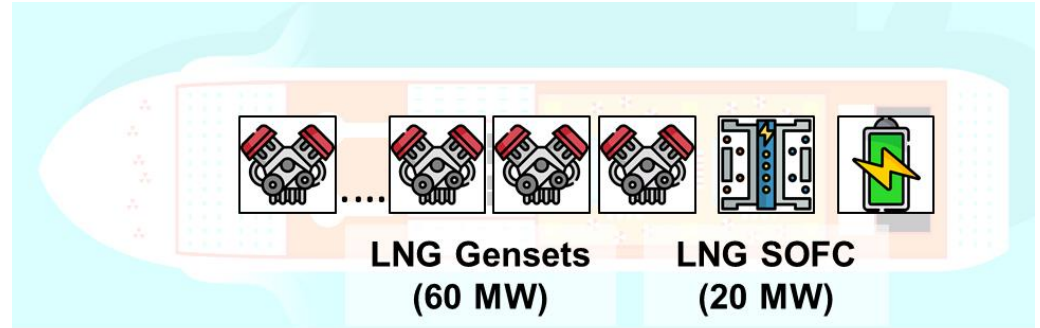
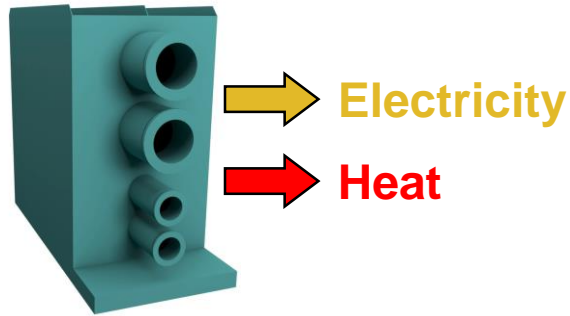
Batteries and fuel cells can yield up to 11.5% energy savings

Results – Fuel Energy Consumption



DC grid promises further energy savings of 2.2% – 4.3%

Solid Oxide Fuel Cells (SOFC)



60% electrical efficiency
85% comb heat & power efficiency

23% GHG reduction expected

- 500 kW LNG SOFC pilot demonstration by 2027
- Research on transient performance, scalability, and fuel flexibility

Conclusions

- PEM Fuel Cells and Batteries can enable up to 11.5% energy savings
- DC grids promise further energy savings of 2.2% - 4.3% over AC grids
- Zero-pollutant ship operation at ports and sensitive areas without fuel penalty



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