

# All About the Boat

## Vessel Energy Consumption and Fuel Efficiency

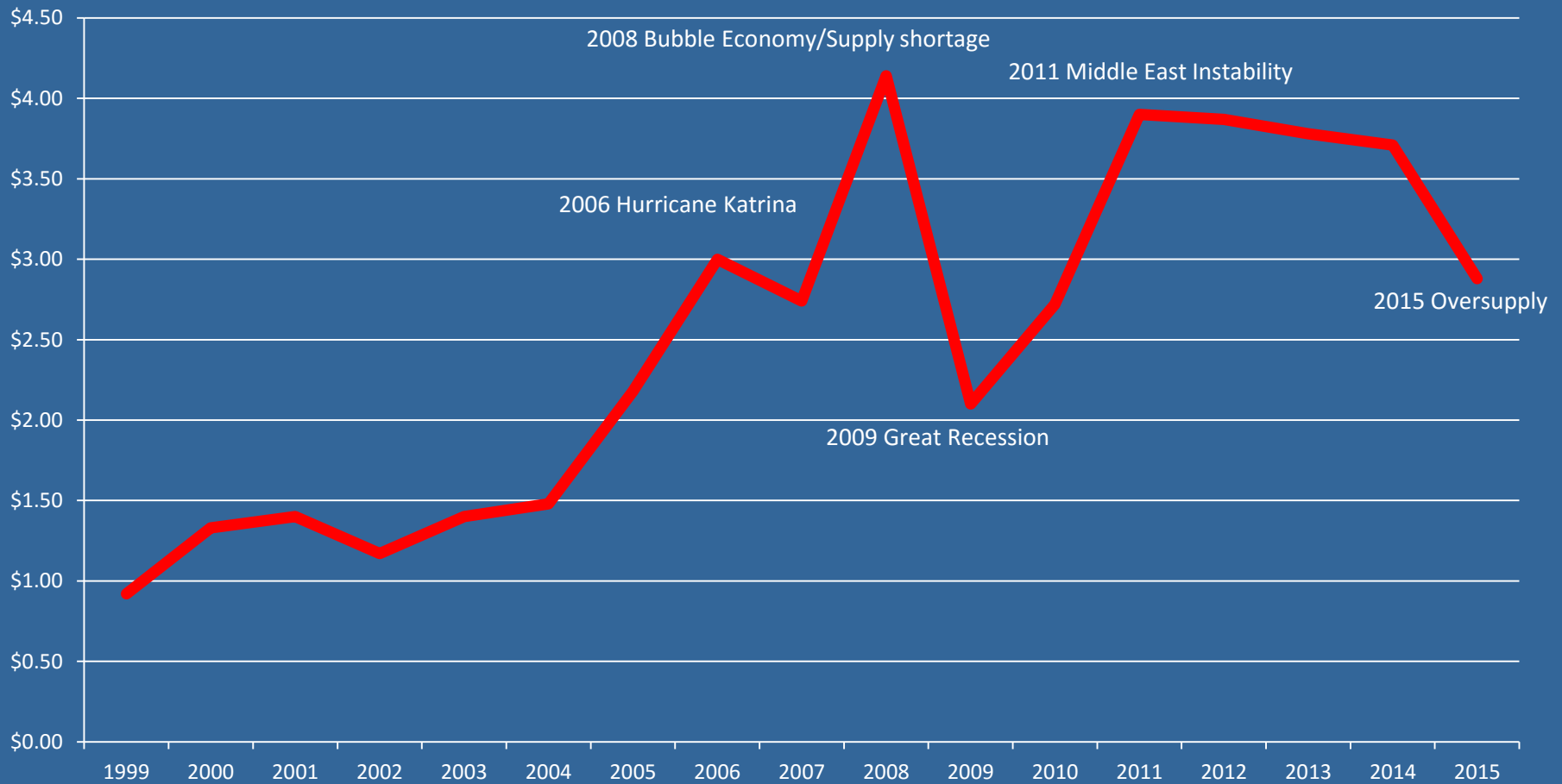


*In collaboration with:*



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# Alaska Fuel Prices



# Effects of High Fuel Prices on Fishermen

- ❑ 2008 Sea Grant study
  - ❑ 33% said they had quit fishing earlier in the season
  - ❑ 31% said they skipped fishing openings they would otherwise have fished
  - ❑ 7% said they fished with other IFQ permit holders, thus eliminating crew jobs
  - ❑ 80% who did fish with a crew said the increased cost of fuel reduced the share paid to crew





# 2010 Energy Audit Project



# Energy Audit Project:



# Energy Audit Project:

## 4 Step Approach

- 1) Develop an operational profile for the vessel
- 2) Establish baseline energy loads for each profile
- 3) Identify high energy consumers
- 4) Research ECM appropriate for the vessel
  - ▣ Implement during upgrades

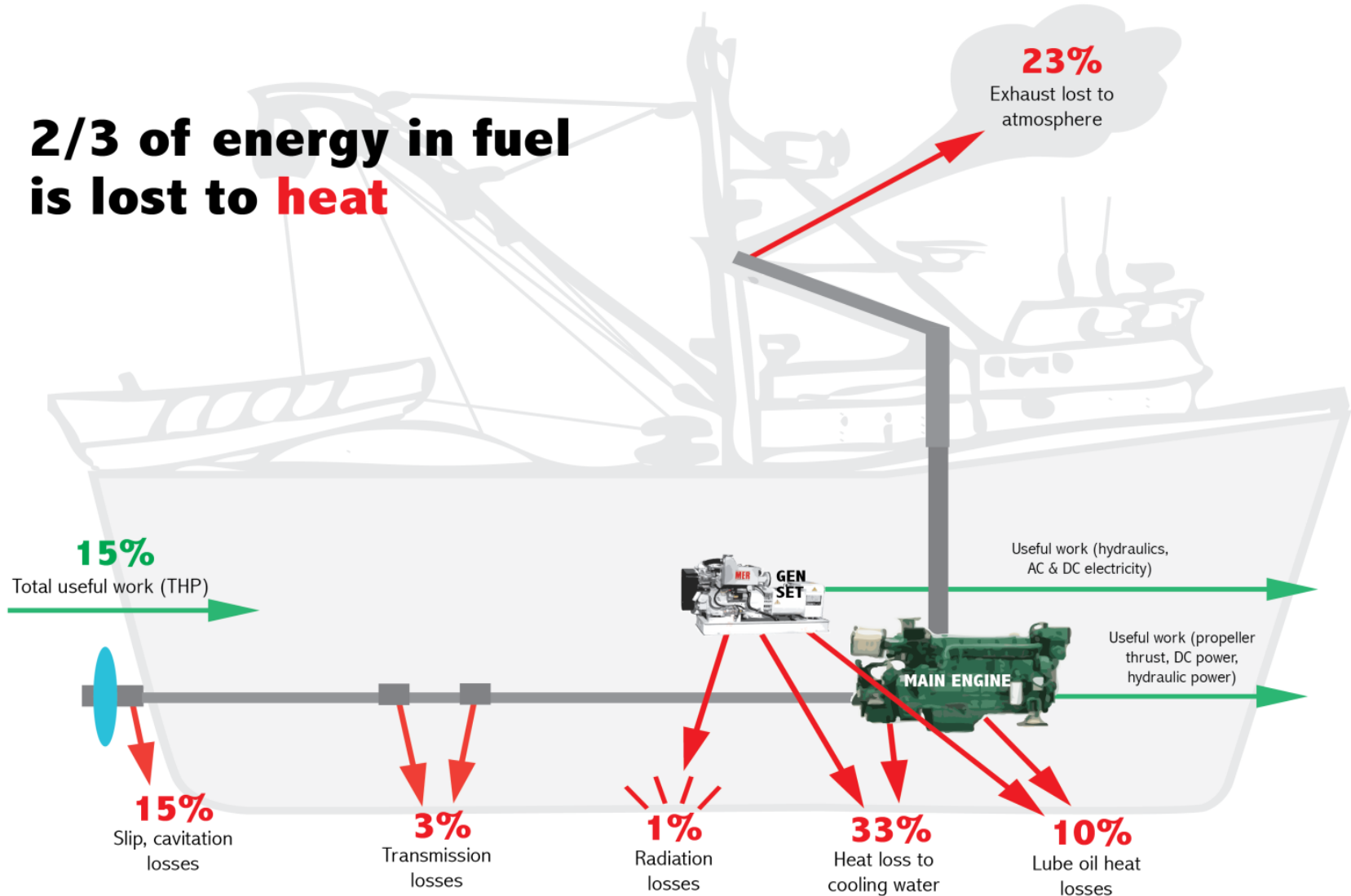
***“Follow the money.  
That’s energy  
management.”***

*Mike Gaffney*



# Fuel Efficiency Basics

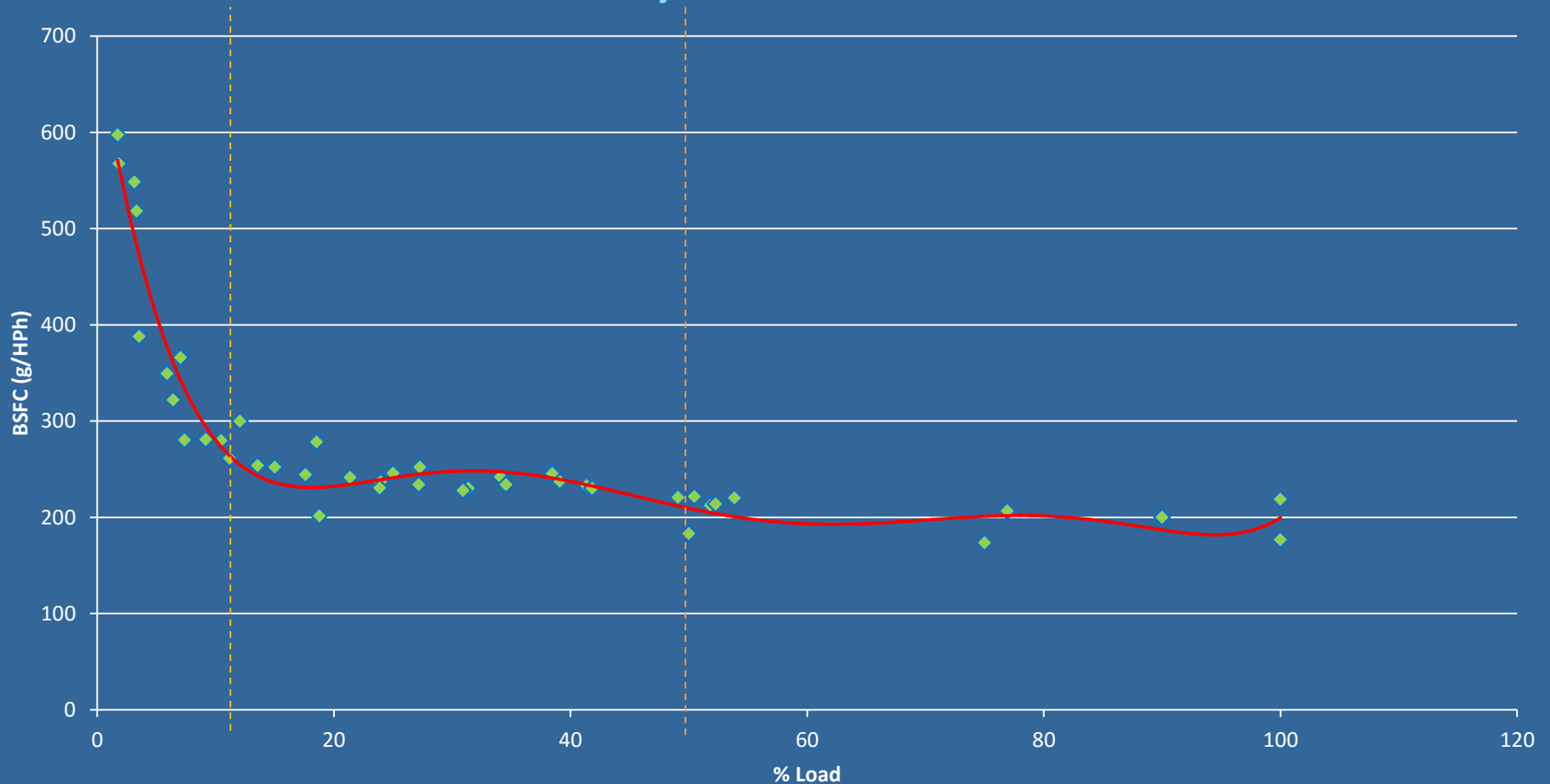
**2/3 of energy in fuel is lost to heat**



# Engine Efficiency:

Engines are most efficient when properly loaded

## 4 Cycle Non Turbo





# Energy Analysis Tool

## Step 1: Vessel Profiles

Vessel Name		
Type		
Length	47	feet
Fuel Cost /gallon	\$4.00	\$/gallon
Shore power cost \$/kWh	\$0.12	\$/kWh
Propulsion Engine #1 Size	165	Horsepower
Propulsion Engine #1 Type	4 cycle non-turbo	▼
Propulsion Engine #2 Size	0	HP
Propulsion Engine #2 Type	NA	▼
Auxiliary Engine #1 size	50	HP
Auxiliary Engine #1 Type	4 cycle turbo	▼
Aux Generator Engine #2 Size	0	HP
Aux Generator Engine #2 Type	NA	▼

If you know the kW for your engine, use the calculator below to convert the kW number into HP.

### KW to HP Conversion

KW	HP
25	33.5

Operating Mode	Name (e.g., Ice troll, gillnet, family outing)	Propulsion Engine #1		Propulsion Engine #2		Aux Engine #1	Aux Engine #2
		Hrs Transit	Hrs Fishing	Hrs Transit	Hrs Fishing	Hrs Fishing	Hrs Fishing
1	Longline	125	160	0	0	15	0
2	Ice Troll	70	150	0	0	10	0
3	Freeze Troll	160	480	0	0	450	0
4	Misc	40	20	0	0	0	0
<b>Total</b>		<b>395</b>	<b>810</b>	<b>0</b>	<b>0</b>	<b>475</b>	<b>0</b>
		Total hrs	<b>1205</b>	Total hrs	0		

Estimate Hydraulic System Condition	Good	▼	Calculated Efficiency	0.8
Estimate Alternator Performance	Standard	▼		0.7

# Energy Analysis Tool

## Step 1: Vessel Profiles

Propulsion Maintenance Cost

#1 Main Engine Maintenance	Interval (hrs.)	Cost (\$)	hourly cost \$/hr.
Oil Change	300	\$200.00	\$0.67
Annual misc. repair	1,200	\$500.00	\$0.42
Minor overhaul	5,000	\$1,500.00	\$0.30
Major overhaul	30,000	\$25,000.00	\$0.83
Other	0	\$0	#DIV/0!
Other	0	\$0	#DIV/0!
Total			\$2.22

#2 Main Engine Maintenance	Interval (hrs.)	Cost (\$)	cost \$/hr.
Oil Change	0	\$0.00	#DIV/0!
Annual misc. repair	0	\$0.00	#DIV/0!
Minor overhaul	0	\$0.00	#DIV/0!
Major overhaul	0	\$0.00	#DIV/0!
Other	0	\$0	#DIV/0!
Other	0	\$0	#DIV/0!
Total			\$0.00

Auxiliary Engine Maintenance Cost

#1 Aux Engine Maintenance	Interval (hrs.)	Cost (\$)	hourly cost \$/hr.
Oil Change	200	\$50.00	\$0.25
Annual misc. repair	500	\$300.00	\$0.60
Minor overhaul	2,500	\$1,000.00	\$0.40
Major overhaul	20,000	\$10,000.00	\$0.50
Other	0	\$0	#DIV/0!
Other	0	\$0	#DIV/0!
Total			\$1.75

#2 Aux Engine Maintenance	Interval (hrs.)	Cost (\$)	hourly cost \$/hr.
Oil Change	0	\$0.00	#DIV/0!
Annual misc. repair	0	\$0.00	#DIV/0!
Minor overhaul	0	\$0.00	#DIV/0!
Major overhaul	0	\$0.00	#DIV/0!
Other	0	\$0	#DIV/0!
Other	0	\$0	#DIV/0!
Total			\$0.00

Hydraulic System Maintenance

Hydraulic system Maintenance	Interval (hrs.)	Cost (\$)	hourly cost \$/hr.
Oil Change	3,000	\$300.00	\$0.10
Annual misc. repair	500	\$100.00	\$0.20
Minor overhaul	0	\$0.00	#DIV/0!
Major overhaul	8,000	\$3,000.00	\$0.38
Other	0	\$0	#DIV/0!
Other	0	\$0	#DIV/0!
Total			\$0.68

Refrigeration System Maintenance

Refrigeration system Maintenance	Interval (hrs.)	Cost (\$)	hourly cost \$/hr.
Oil Change	0	\$0.00	#DIV/0!
Annual misc. repair	1,000	\$500.00	\$0.50
Minor overhaul	5,000	\$1,500.00	\$0.30
Major overhaul	10,000	\$500.00	\$0.05
Other	0	\$0	#DIV/0!
Other	0	\$0	#DIV/0!
Total			\$0.85

# Energy Analysis Tool

## Step 2: Baseline energy loads

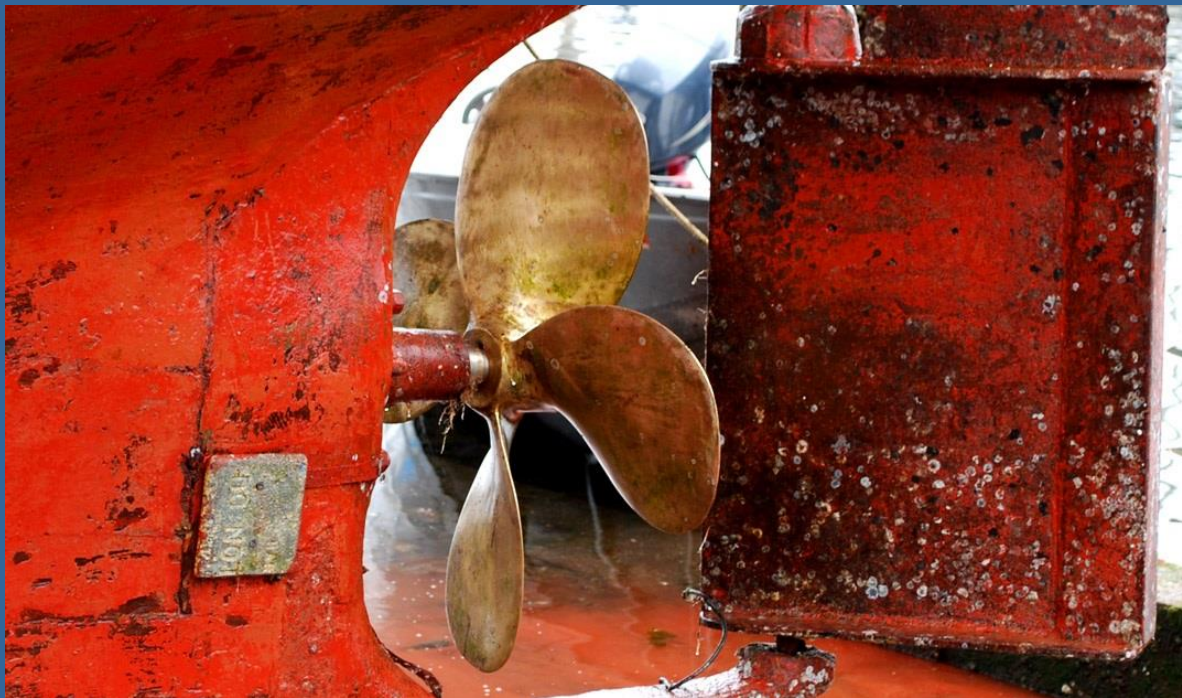
- Propulsion Loads
- Electric Loads
  - ▣ AC
  - ▣ DC
- Hydraulic Loads
- Refrigeration Loads



# Energy Analysis Tool

## Step 2: Propulsion loads

	Propulsion				
	Transit	Fishing	HP	HP	
Speed (kn)	7	2	40.4	2.6	Engine 1
<input type="checkbox"/> Twin Engine Propulsion			0.0	0.0	Engine 2



*\*Values based on Audit measurements*



# Energy Analysis Tool

## Step 2: DC Electric Loads

- 5 categories
  - ▣ DC Hotel Loads
  - ▣ DC Nav Lighting
  - ▣ DC Nav Electronics
  - ▣ Other DC Lighting
  - ▣ DC Deck Loads
- Select equipment and Duty cycle

DC Load		Assumed Power Demand (Amps)	Assumed Power Demand (Watts)	# of devices	% of time used Transit	% of time used Fishing	Main 1	Main 2	Aux 1	Aux 2
DC Hotel Loads	Running bilge pump (with light)	5.6	72.6	0	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	fresh water pump	4.2	54.3	0	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Cabin Fridge through inverter	9.4	122.0	0	0%	0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Window Heater	4.8	63.0	0	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Stove fan (low)	1.6	20.6	0	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Stove fan (High)	2.3	30.3	0	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	ER fan	4.4	57.7	0	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
DC Nav Lights	Running lights (incandescent)	2	26.0	0	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Red Mast Light (incandescent)	0.6	7.6	0	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Anchor light (incandescent)	1.4	18.1	0	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Nav Running lights (3 LED bulb)	0.3	3.6	0	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Red Mast Light (LED)	0.1	1.0	0	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Anchor light LED	0.2	2.3	0	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Other			0	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
DC Nav Electronics	CB radio	0.6	7.5	0	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	CB Transmit	2.5	32.1	0	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	VHF	0.6	7.9	0	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	VHF Transmit	5	64.7	0	0%	0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	single side band	1.8	22.9	0	0%	0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

*\*Values based on Audit measurements*

# Energy Analysis Tool

## Step 2: AC Loads

- 4 broad categories
  - Hotel loads
  - Lighting
    - All Around
    - Deck
    - Other
  - Heating
  - Other AC loads

AC Loads		Capacity (kW)	Fraction of Time Used Transit	Fraction of Time Used Fishing	Main 1	Main 2	Aux 1	Aux 2
					<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hotel Loads	Refrigerator	0.10	0.0%	0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Hot Water Heater	3.17	0.0%	0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Hot Plate 1.5 kW	1.50	0.0%	0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Microwave	1.50	0.0%	0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Other Hotel	1.50	0.0%	0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lighting	All Around Lighting	0	0.0%	0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Deck Lighting	0	0.0%	0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Other Lighting	0	0.0%	0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Other Lighting	0	0.0%	0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other	Heating	0	0.0%	20%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Other AC	0	0.0%	0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Other AC	0	0.0%	0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

*\*Values based on Audit measurements*

# Energy Analysis Tool

## Step 2: Hydraulic Loads



- 4 broad categories
  - Steering loads
  - Hydraulic pump type
  - Deck equipment-  
focus of phase 2 is to  
get more data in  
library
  - Other hydraulic loads

Hydraulic Loads		Assumed Capacity (hp)	Fraction of Time Used Transit	Fraction of Time Used Fishing	Main 1	Main 2	Aux 1	Aux 2
Match Operating Mode 1					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Steering Pumps	Sm Steering hyd pump	0.50	0.0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	V-20 Steering pump	1.50	0.0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Deck Hydraulics Pumps	Deck Hydraulic pump engaged	0.5	0.0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Pressure compensating pump	1.4	0.0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Deck Hyd Equip	Washdown Pump	0.75	0.0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Anchor Winch	20.00	0.0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Troller 3/4 hp Gurdy	0.25	0.0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Longline Sheave	3.00	0.0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Auto Line system	5.00	0.0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Gill Net Drum	0.00	0.0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Power Roller	0.00	0.0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Seine winch	0.00	0.0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Other Deck Equip	0.0	0.0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other	Other Hyd Equip	0.0	0.0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

*\*Values based on Audit measurements*

# Energy Analysis Tool

## Step 2: Refrigeration Loads

- ❑ ☐ Blast freezer
  - ❑ Compressor
  - ❑ Evaporator fan
  - ❑ Condenser pump
- ❑ RSW
- ❑ Compressor
- ❑ Condenser pump
- ❑ Recirculation fan

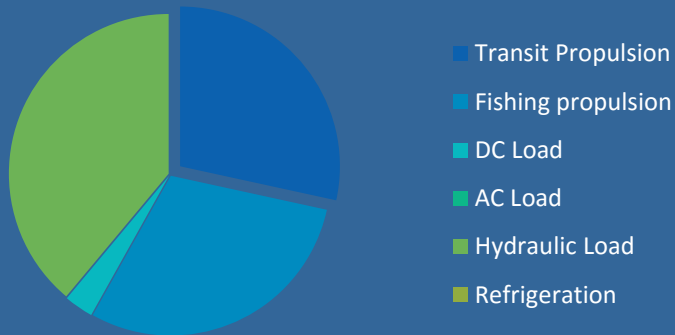
Refrigeration Loads								
Match Operating Mode 1		HP	% of time used Transit	% of time used Fishing	Main 1	Main 2	Aux 1	Aux 2
					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Blast Freeze system	7.5 ton compressor Max	16.2198391	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	7.5 ton compressor Ave	8.57908847	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Evaporator Fan	0.67024129	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Saltwater condenser pump	1.60857909	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	other		0%	0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
RSW System	System 1	10.92	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	System 2	10.92	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Condenser pump 1	0	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Condenser Pump 2	0	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Recirculation Pump 1	0	0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Other		0%	0.0%	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

*\*Values based on Audit measurements*

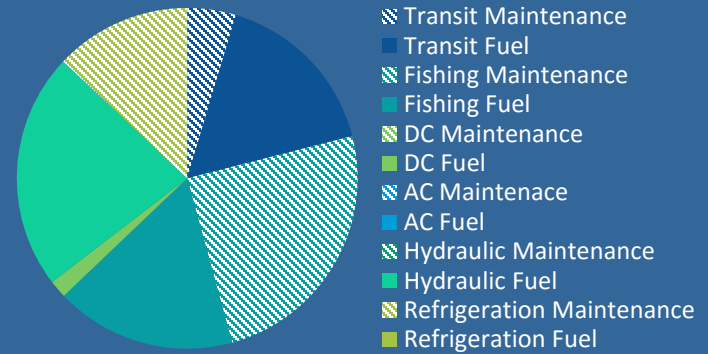


# Energy Analysis Tool

## Fuel Use by Load Type

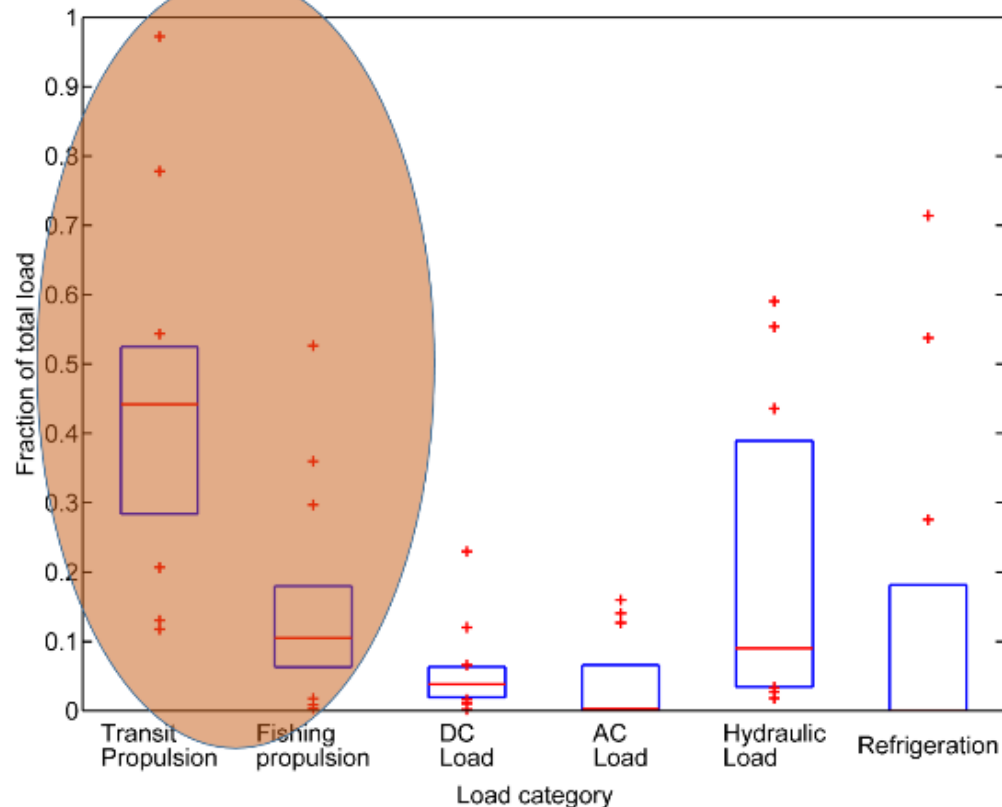


## Cost by Load Type



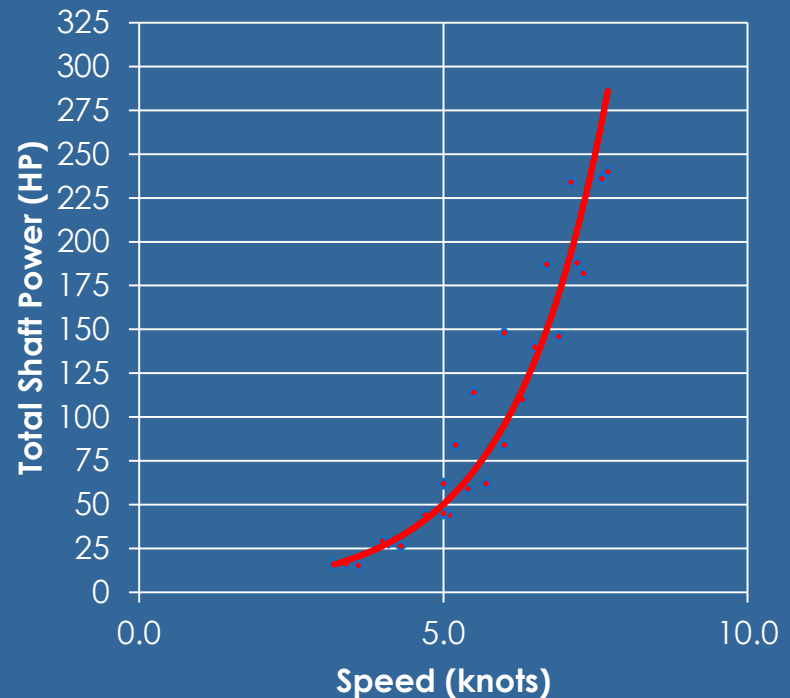
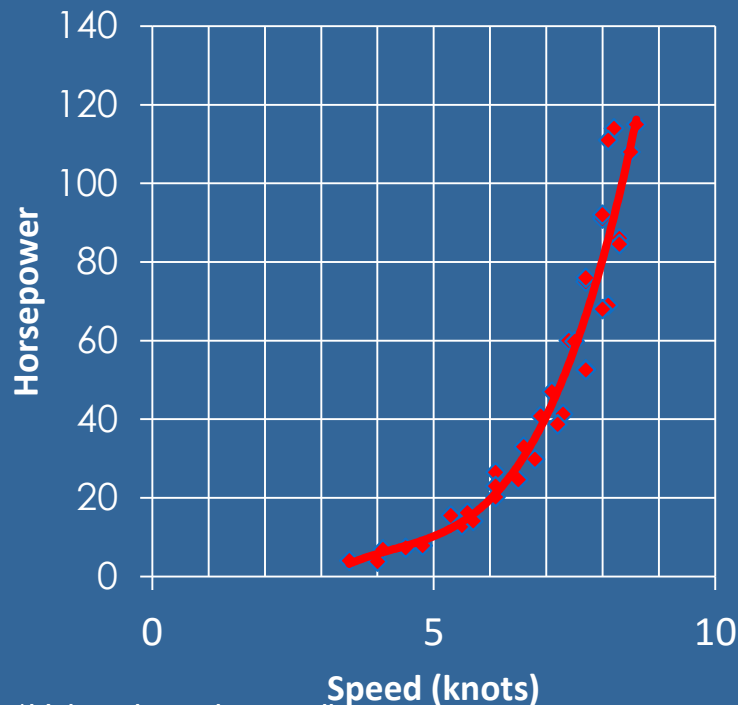
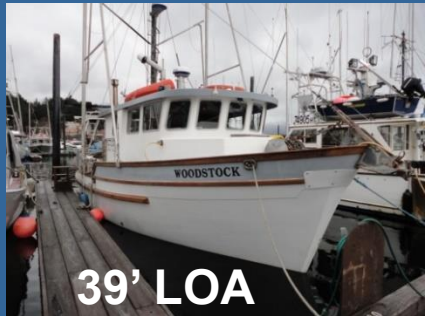
# What the Energy Audit Revealed:

## Propulsion



# What the Energy Audit Revealed:

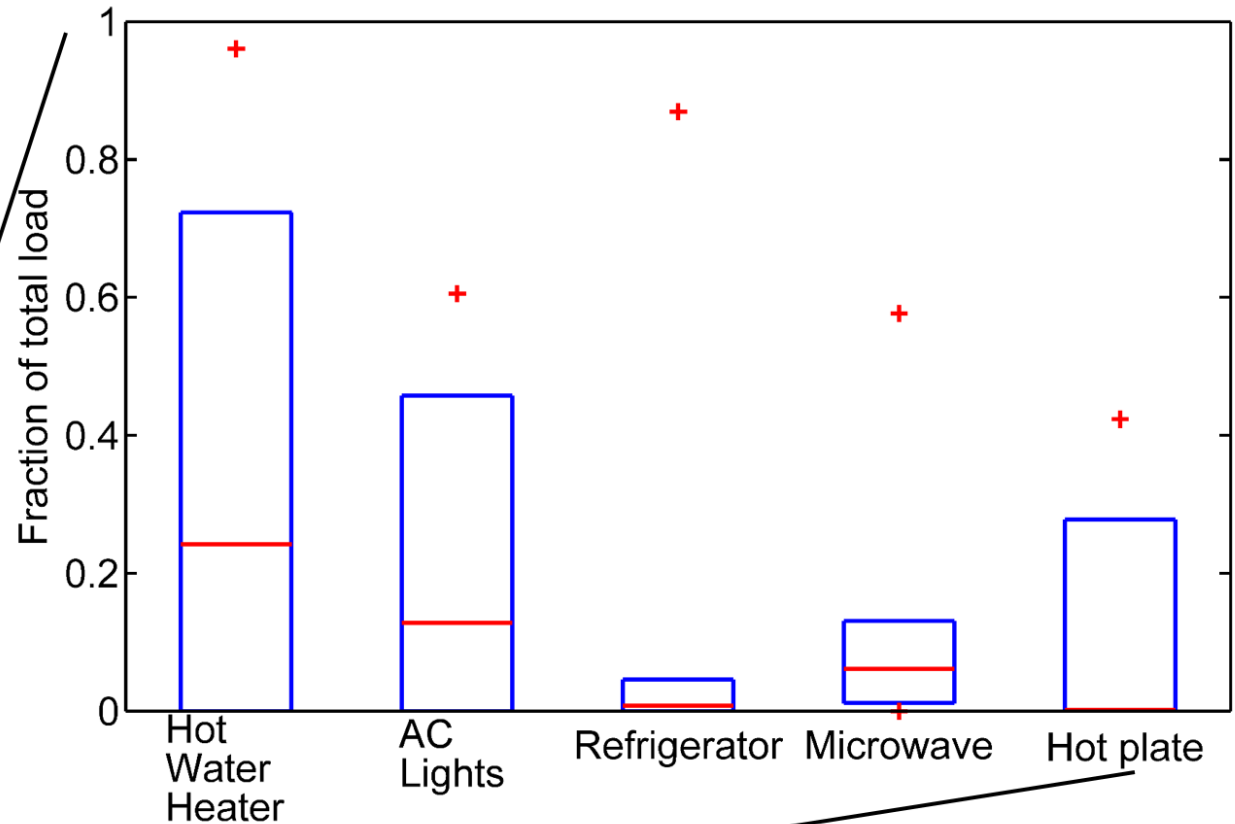
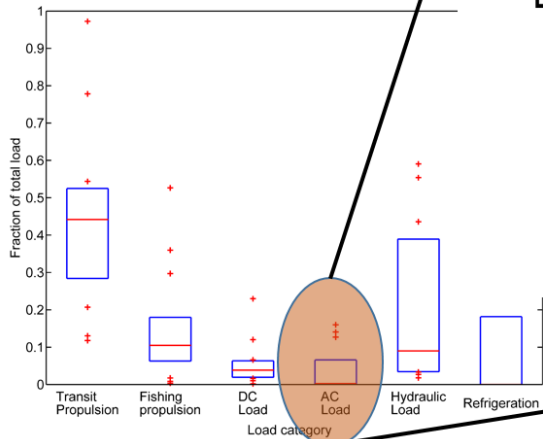
## Propulsion



\*Values based on audit measurements

# What the Energy Audit Revealed:

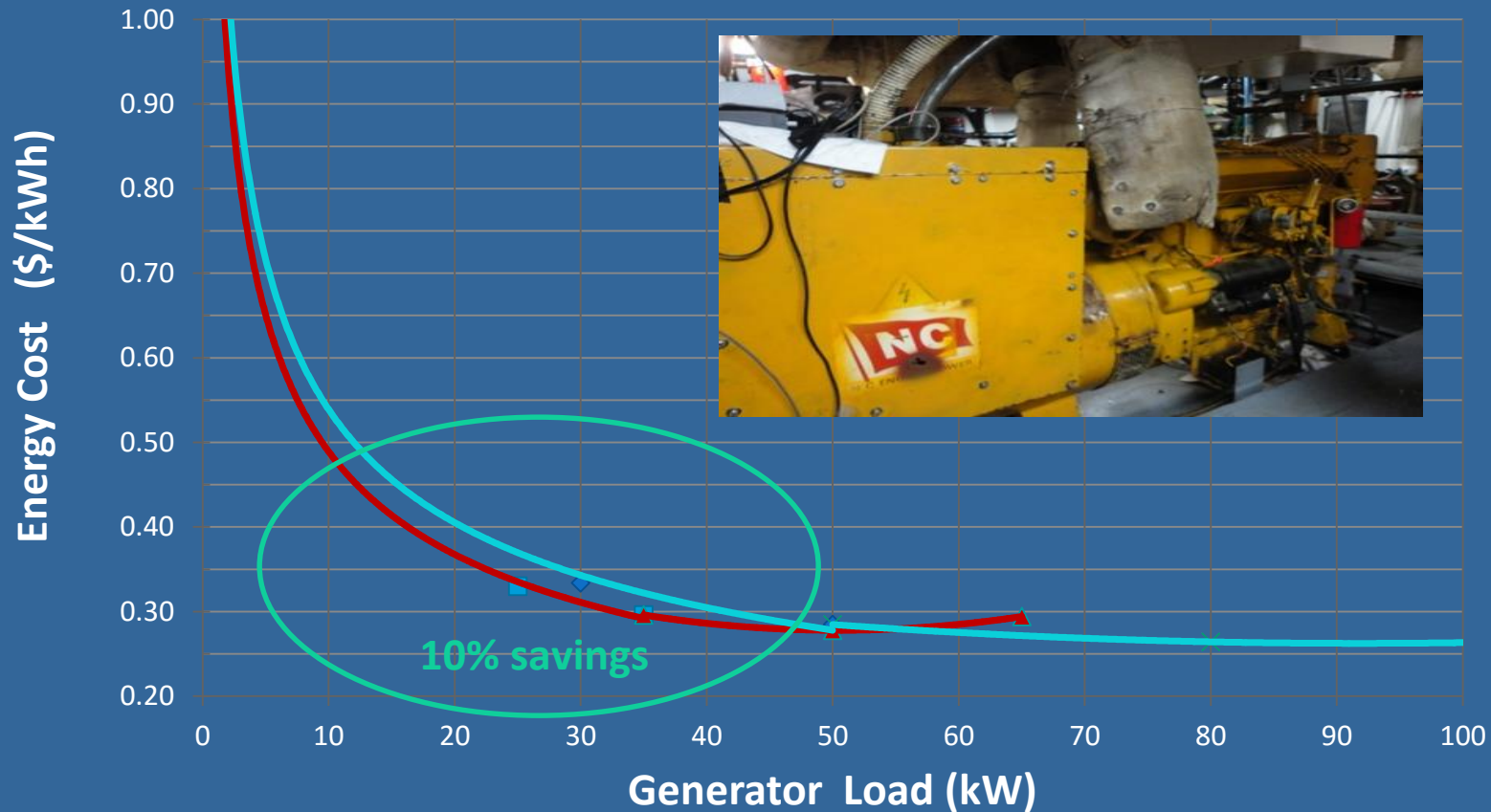
## AC Loads





# Energy Analysis Tool

## Step 2: AC Loads



105 kW and 55 kW Gensets

# Motor Efficiency and Savings

- ❑ **68% Standard Efficiency Motor - 1 HP Circulating Pump**
  - ❑ Input Power: 1.47 HP
  - ❑ Cost for 1000 hrs/yr operation @ \$0.5/HP: \$735
  - ❑ Purchase Price :\$321
- ❑ **82.5% Premium Efficiency Motor - 1 HP Circulating Pump**
  - ❑ Input Power: 1.21 HP
  - ❑ Cost for 1000 hrs/yr operation @ \$0.5/HP: \$605
  - ❑ Purchase Price: \$446



**IE Class 3**

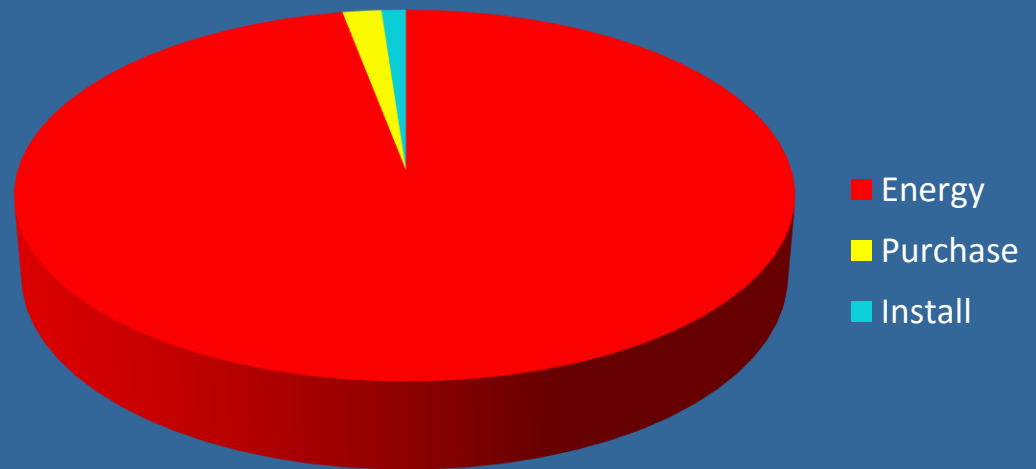
**Cost difference: \$125**  
**Annual savings: \$130/year**  
**Motor life: 10 years**  
**Payback: 1 yr**

# Motor Efficiency and Savings

Purchase price: \$321  
Install cost: \$100  
Operating cost/yr.: \$735

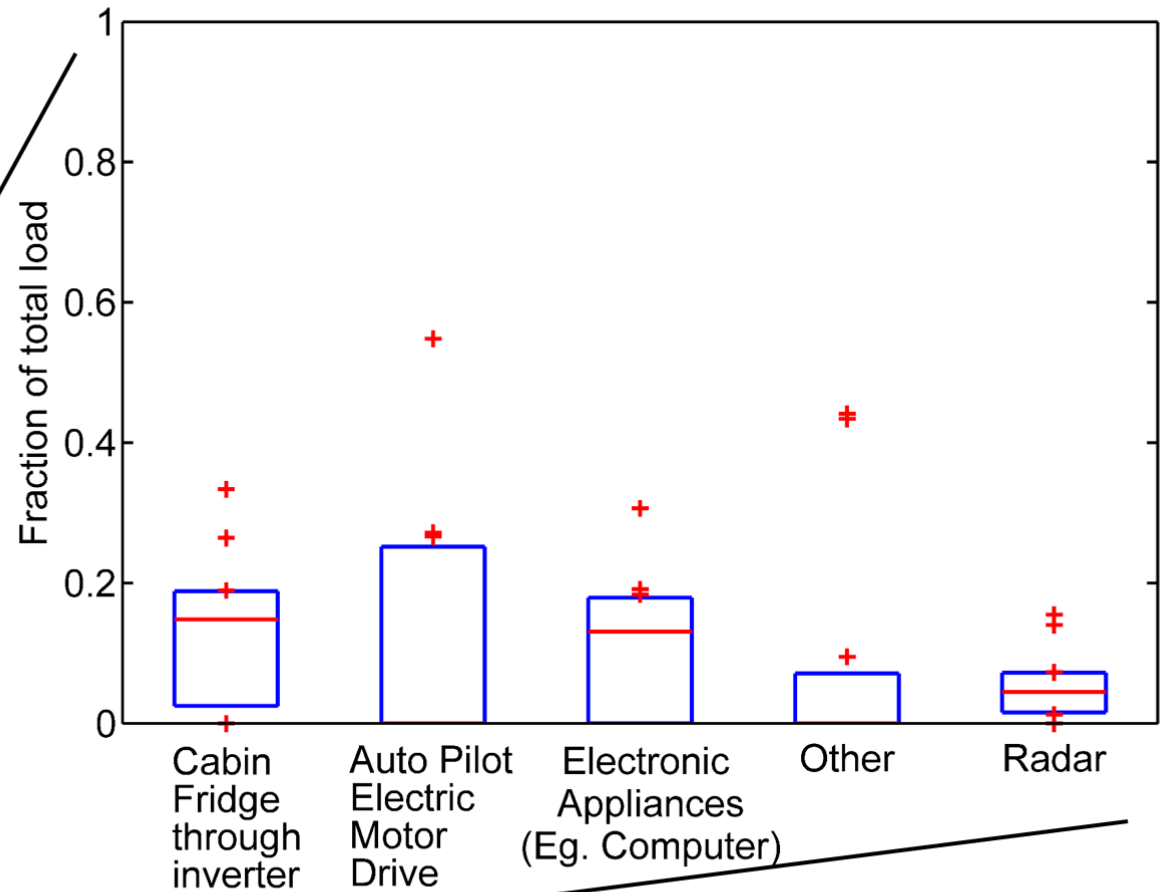
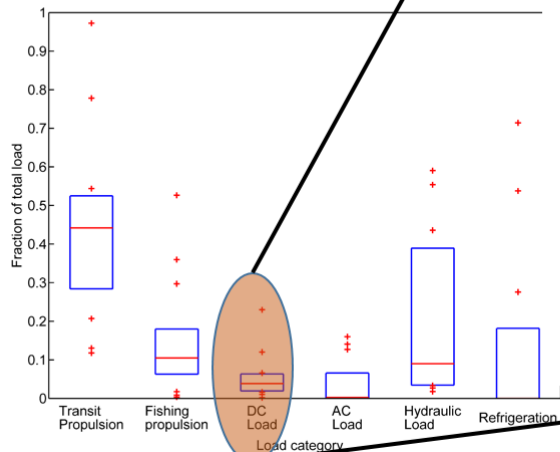
Motor life: 10 years  
Total operating cost: **\$7,350**  
% operating costs: **95%**  
% purchase and install: **5%**

10 yr Motor Life Cycle cost



# What the Energy Audit Revealed:

## DC Loads





# What the Energy Audit Revealed:

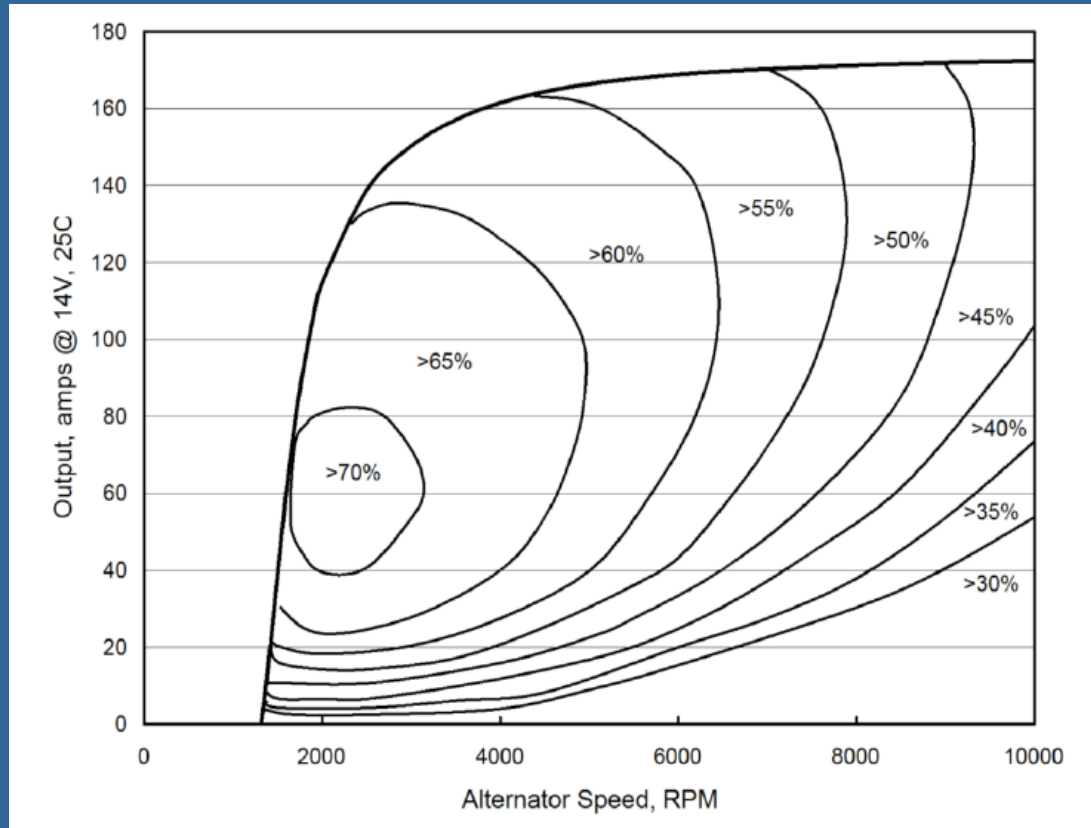
## DC Loads

- ❑ **DC power is not free**
  - ❑ DC electrical costs range from \$388 to over \$1000 per season
- ❑ **Belt type and tension matter**
  - ❑ V belts are 95% efficient
  - ❑ Serpentine belts can be 99% efficient
- ❑ **Alternator efficiency depends on design and RP**
  - ❑ Standard efficiency 45% to 55% (up to \$.70/kW/hr.)
  - ❑ Premium efficiency 55% to 85%



# What the Energy Audit Revealed:

## DC Loads



White Paper: Improving Alternator Efficiency Measurably Reduces Fuel Cost:  
Mike Bradfield, MSME, Remy Inc

# What the Energy Audit Revealed:

## DC Loads

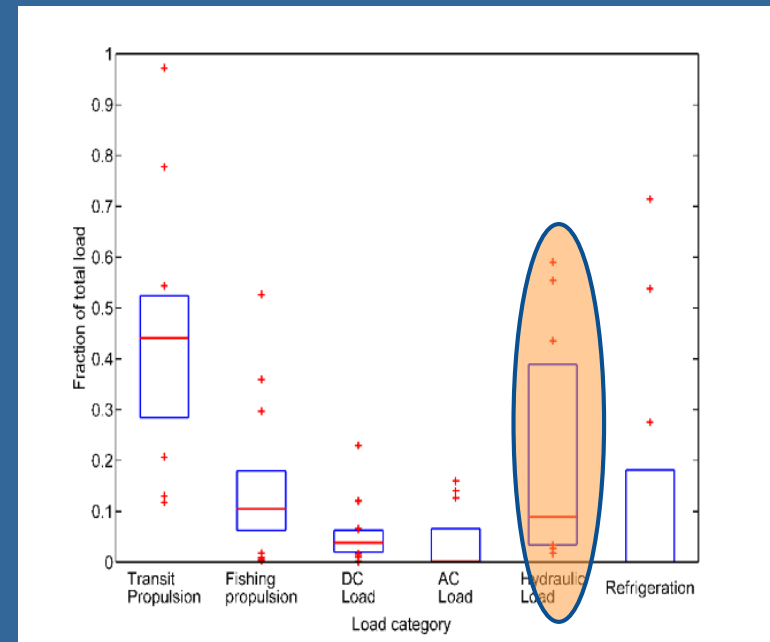
- ❑ Turn off lights, fans, appliances, pumps, etc. when not needed.
- ❑ Replace incandescent bulbs with CFL or LED.
- ❑ Switch to v-rib, cogged or synchronous drive belt. Maintain proper belt tension and prevent slippage.
- ❑ Size pulley so that alternator runs at design speed (commonly 4500-6000 rpm).
- ❑ At replacement time select premium efficiency alternator (not “high output”)



# What the Energy Audit Revealed:

## Hydraulic Loads

- On some vessels, hydraulics accounted for more than 50% of the energy loads.
- Many vessels were configured so that pump runs continuously when engine is running.
  - Fuel use in stand-by mode was measured at .25GPH for a small pump



# What the Energy Audit Revealed:

## Hydraulic Loads

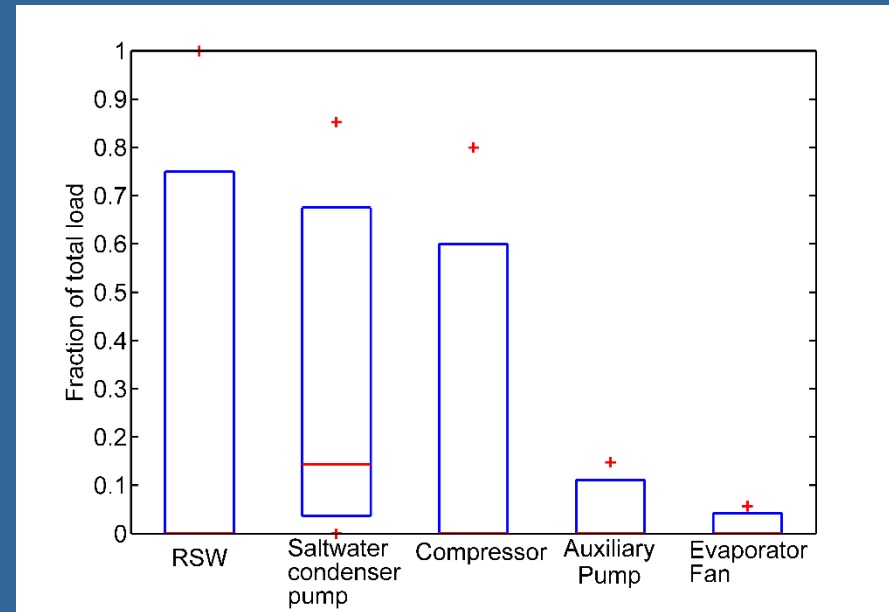
- ❑ De-clutch hydraulics when not in use.
- ❑ Track down and eliminate sources of heat and noise.
- ❑ Ensure all line runs are straight as possible with no corners or constrictions.
- ❑ Change fluid and filter regularly, and use lightest grade fluid recommended by equipment makers.
- ❑ Consider replacing hydraulics with more efficient electric drive where feasible.



# Energy Analysis Tool

## Step 2: Refrigeration Loads

- ❑ Refrigerated seawater chilling and blast freezing can be run mechanically, electrically or hydraulically.
- ❑ Some run off main engine but more commonly a diesel auxiliary powers the refrigeration.
- ❑ Refrigeration is a major energy consumer. On some vessels it's more than half of all energy consumption.
- ❑ The compressor is the biggest energy consumer in both chilling and freezing systems. Others are seawater pump for condenser and circulation pump (RSW) and fan (blast freezer).





# Energy Analysis Tool

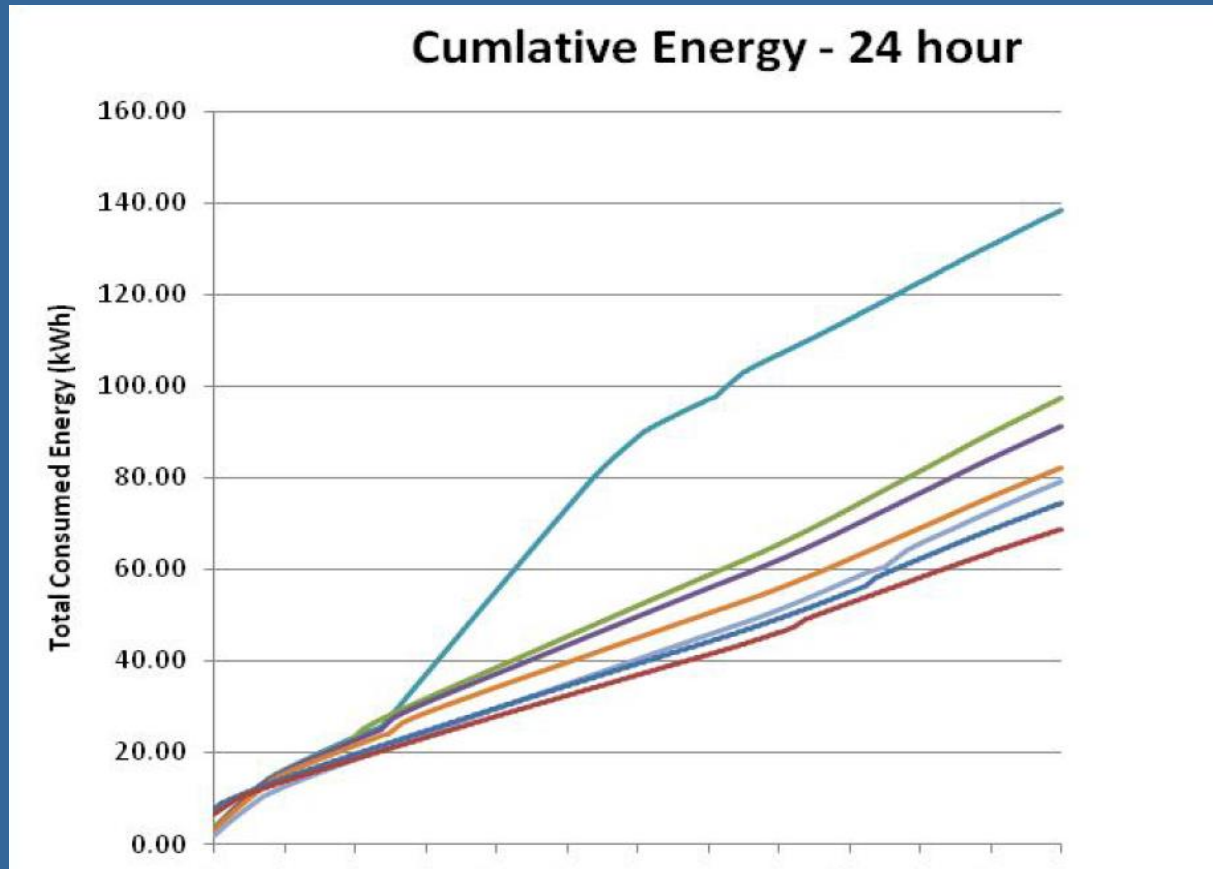
## Step 2: Refrigeration Loads

- ❑ Compressor technology is improving
  - ❑ VFD controllers
- ❑ Maintenance and operation can have a big impact on cost.



# Energy Analysis Tool

## Step 2: Refrigeration Loads



**Maintenance vs. Technology**  
**Compressor Power on Reefer Containers**

# Motors Control

- ❑ VFD Controllers adjust AC motor RPM's to meet torque demand
- ❑ At 63% speed a motor load consumes only 25% of its full-speed power

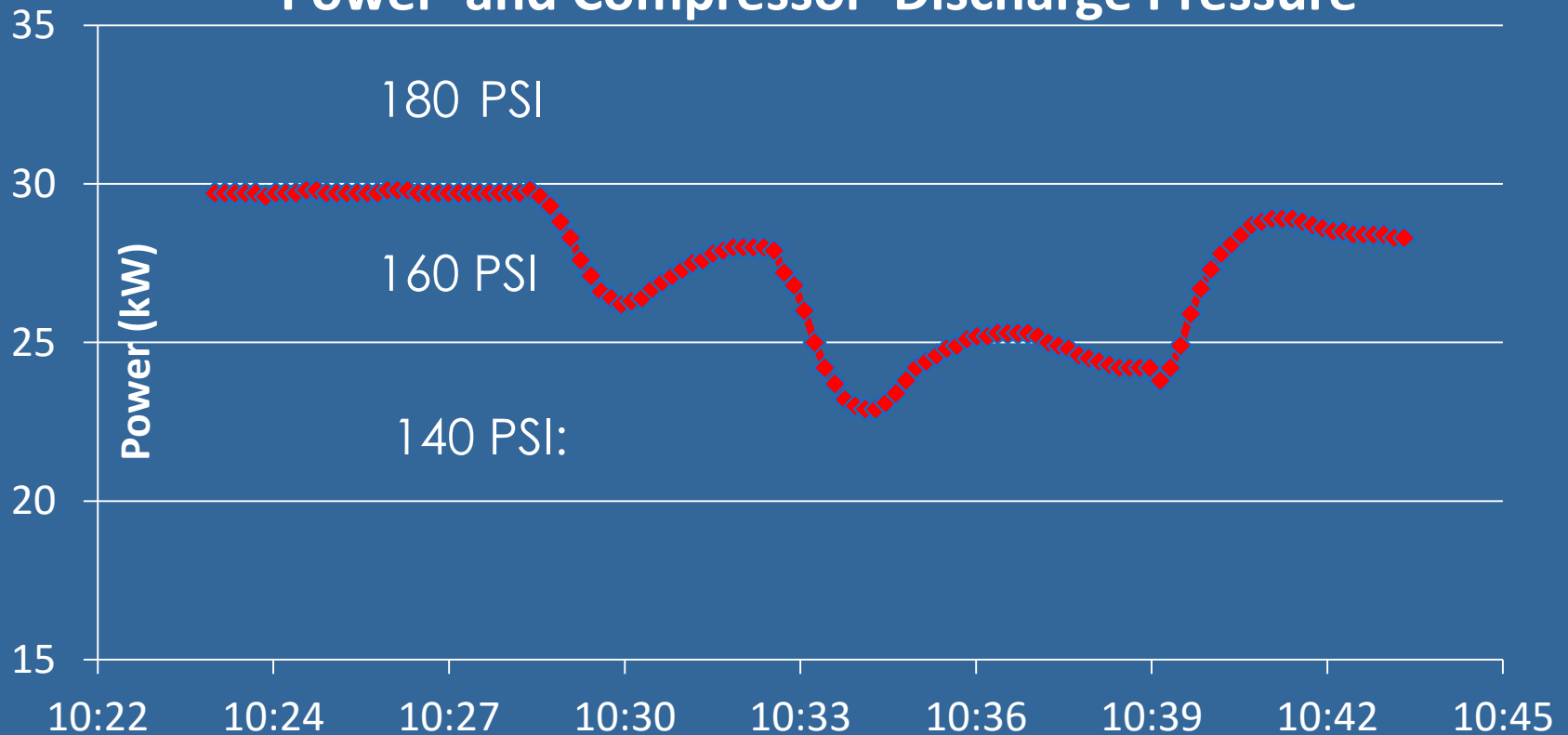
Motor Variable Frequency Drives (VFD)  
Steering Gear, Fans, Pumps, Winches



# Energy Analysis Tool

## Step 2: Refrigeration Loads

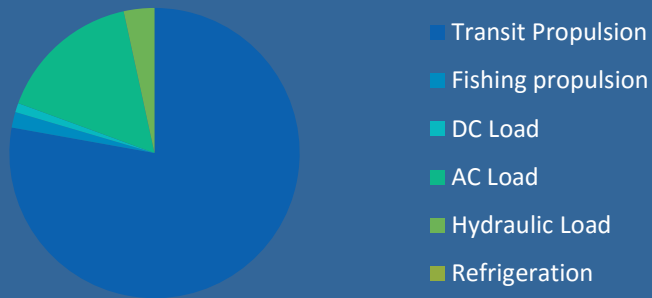
**RSW Compressor:  
Power and Compressor Discharge Pressure**



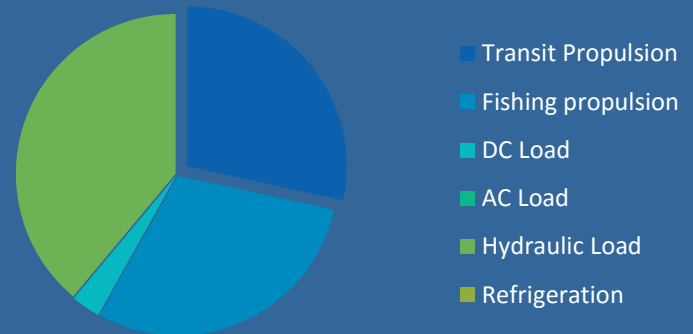
# Diverse Fleet

Each with unique ECM's

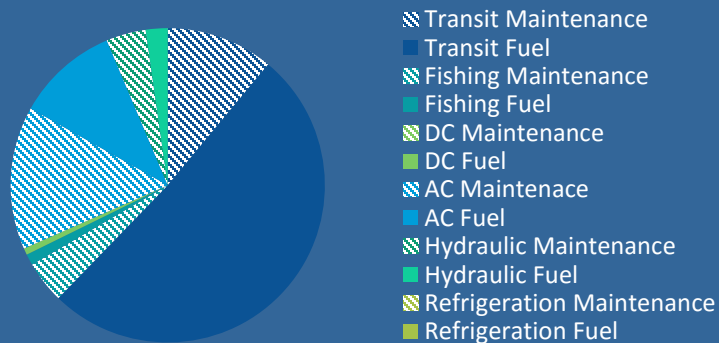
## Fuel Use by Load Type



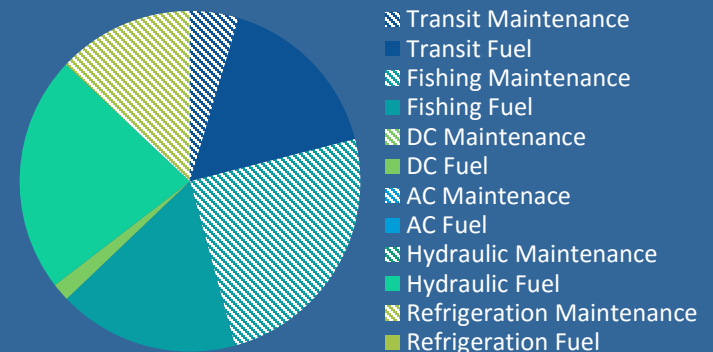
## Fuel Use by Load Type



## Cost by Load Type



## Cost by Load Type



# All About the Boat

## Vessel Energy Consumption and Fuel Efficiency



*In collaboration with:*



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