On-Board Electrical Use A.C. Systems

Alaska Fisheries Development Foundation

University of Alaska Sea Grant Marine Advisory Program

Alaska Longline Fishermen's Association

Many vessels have AC (alternating current) electrical systems

Nominally 110-volt, normally operate at 120-volts. Some are 240 or 480 volts. Single or three-phase.

Normally produced by one or more on-board diesel engine powered generator sets.

Small AC loads (up to 3 kW max) may be supplied by an inverter on the DC system.

Shore power can supplant on-board generation when tied to a dock.

Used for heavier electrical loads such as large radars, big pumps, steering motors on large vessels, refrigeration compressors, high capacity external lighting, as well as "hotel" loads like refrigerators, microwaves, coffee makers, TV and sound systems.

AC system voltage can be deadly if a person becomes the conductor between source and ground.

AC Electrical Systems

On-board generators experience the same inefficiencies as propulsion systems.

Sixty percent of the fuel energy delivered to a diesel generator is lost to heat and friction.

An optimally loaded big generator loses another 3%, a smaller unit about 25%

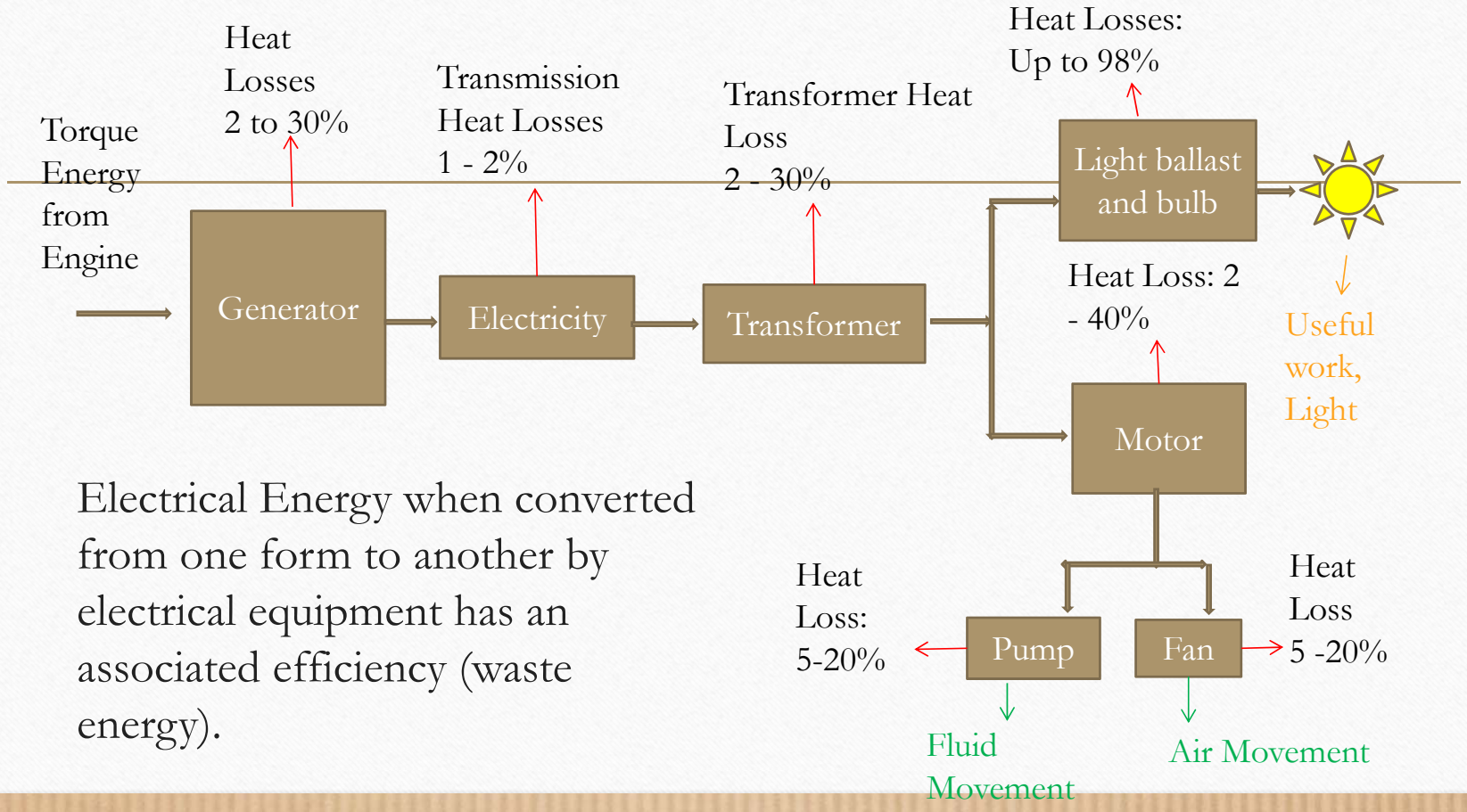
Each kW of 120-volt AC power requires about 2 hp of diesel engine power, or 1 gal of fuel every 8 hrs. if optimally loaded.

Under-loaded gensets are significantly less efficient. A unit run at 10% of rated output uses 40-50% more fuel per kW than when run at full load.

Undersized wiring, improperly maintained terminals, inadequate grounding, etc. are safety hazards, can cause fires, and rob energy.

.

Electrical Equipment Efficiency



Electrical Energy when converted from one form to another by electrical equipment has an associated efficiency (waste energy).

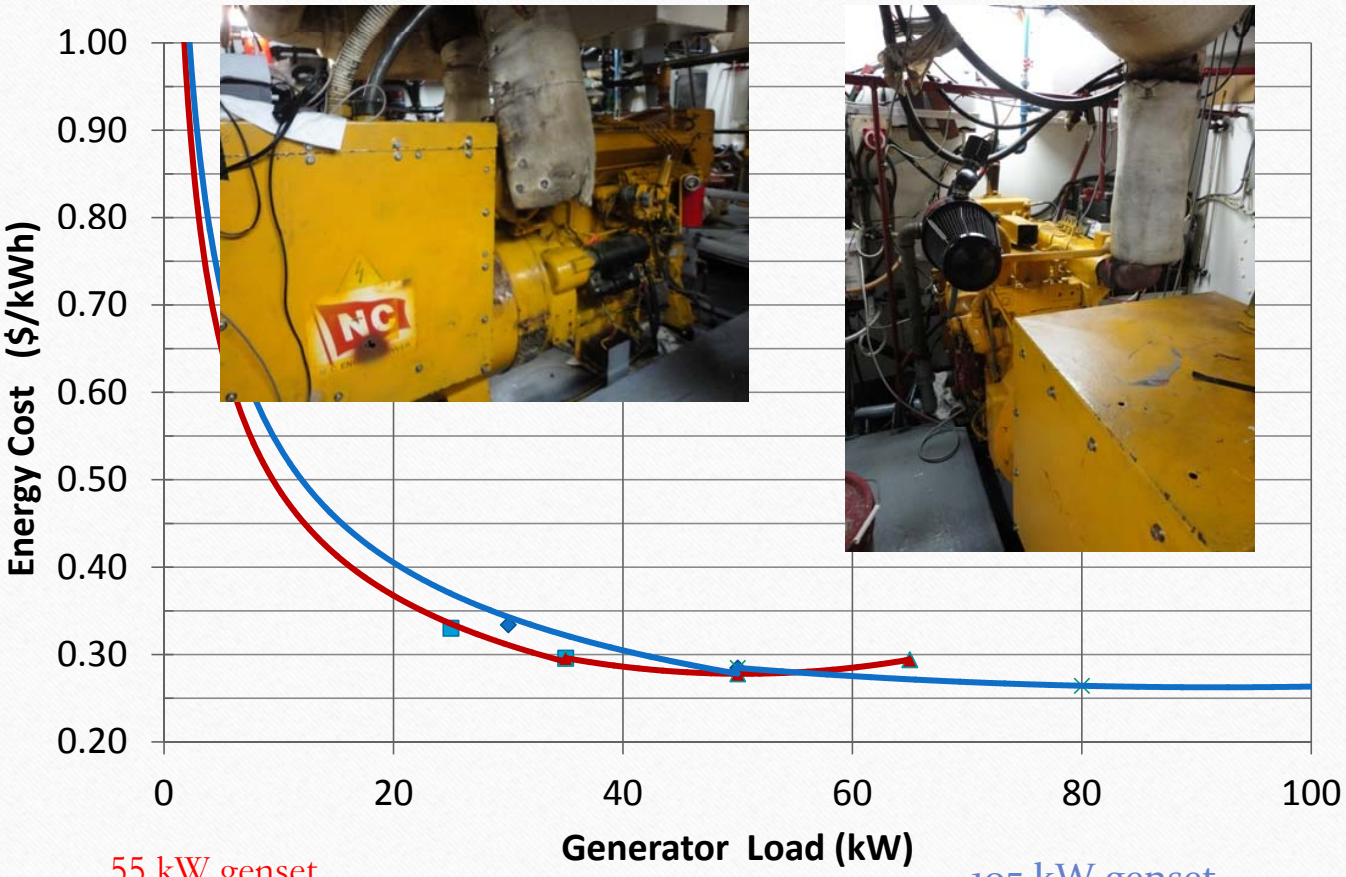
AC Electrical Systems

What the Fishing Vessel Energy Audit Project Revealed

- Most installed generators are oversized and under-loaded.
- Each kW costs 12-15% more when operating at 40% rather than 80% of rated output.*
- A small genset running at capacity can save 20% from cost of running lightly-loaded big one.

**Pertains to mechanically-injected diesel generators. Electronic engines are more efficient at low output.*

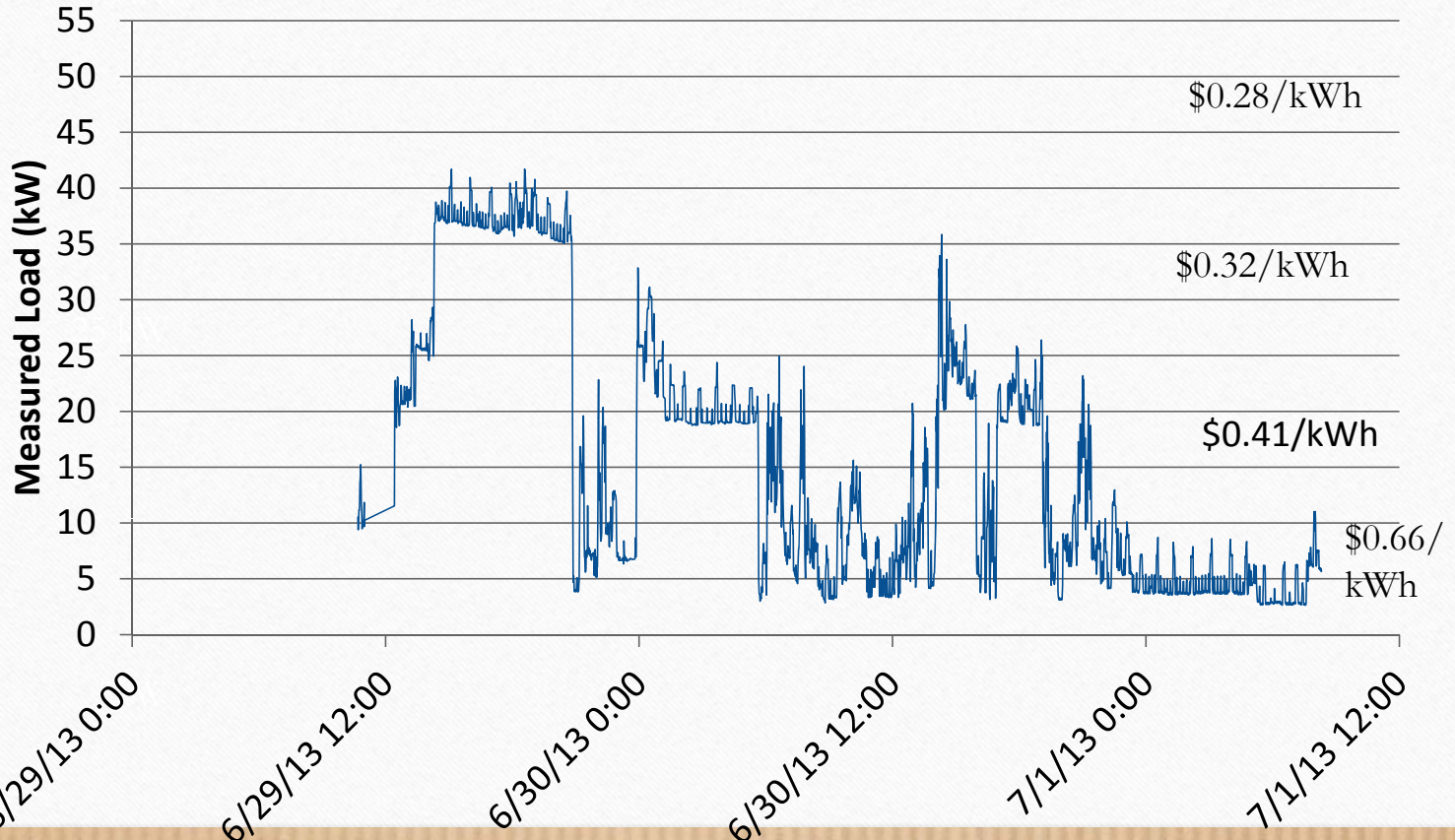
F/V Savage Aux Power: 105 kW and 55 kW Gensets



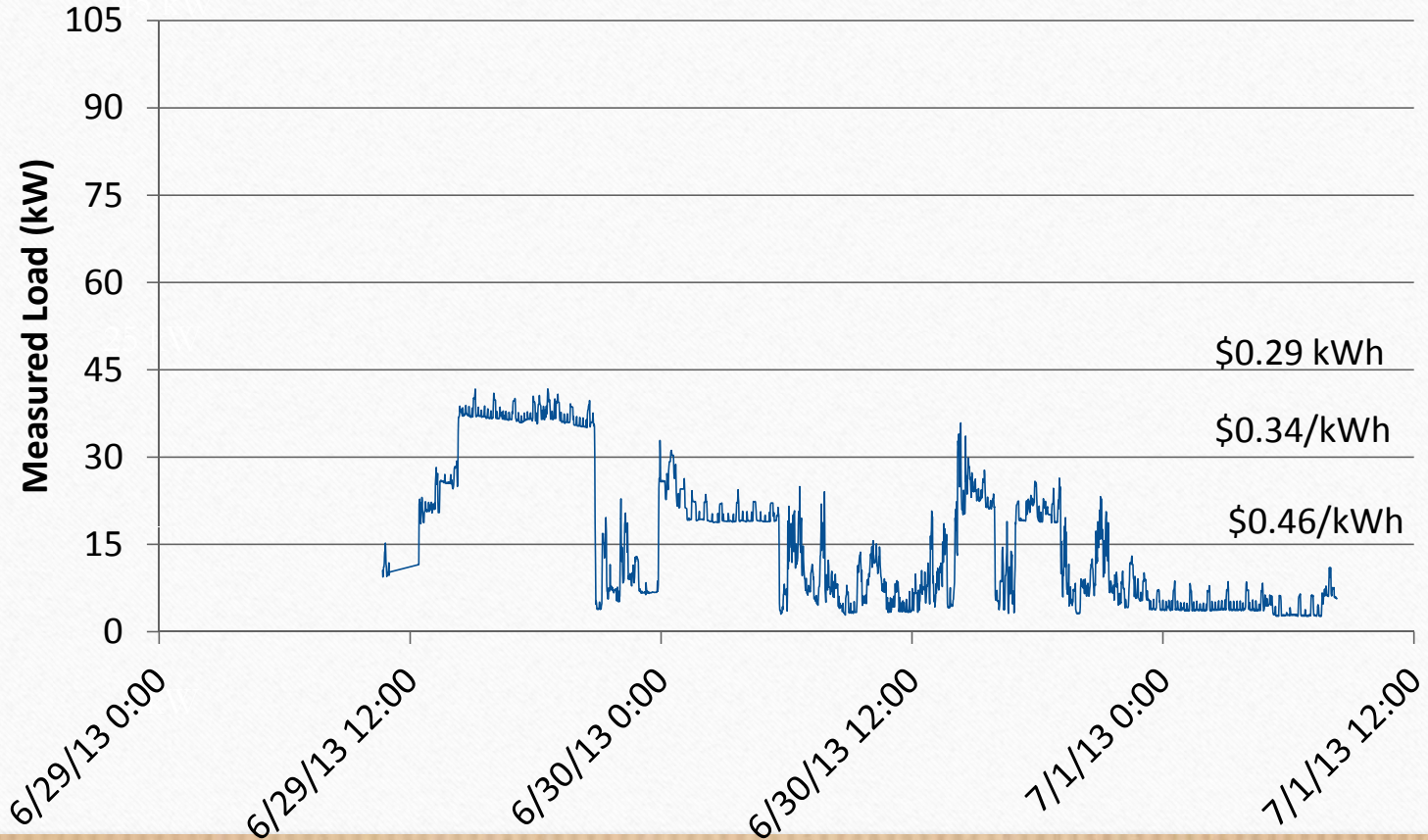
55 kW genset

105 kW genset

F/V Savage Aux Load 2 day Trip
55 KW Cat Genset



Savage: Aux Load 2 Day Trip
105 kW Cat Genset
Vessel Load



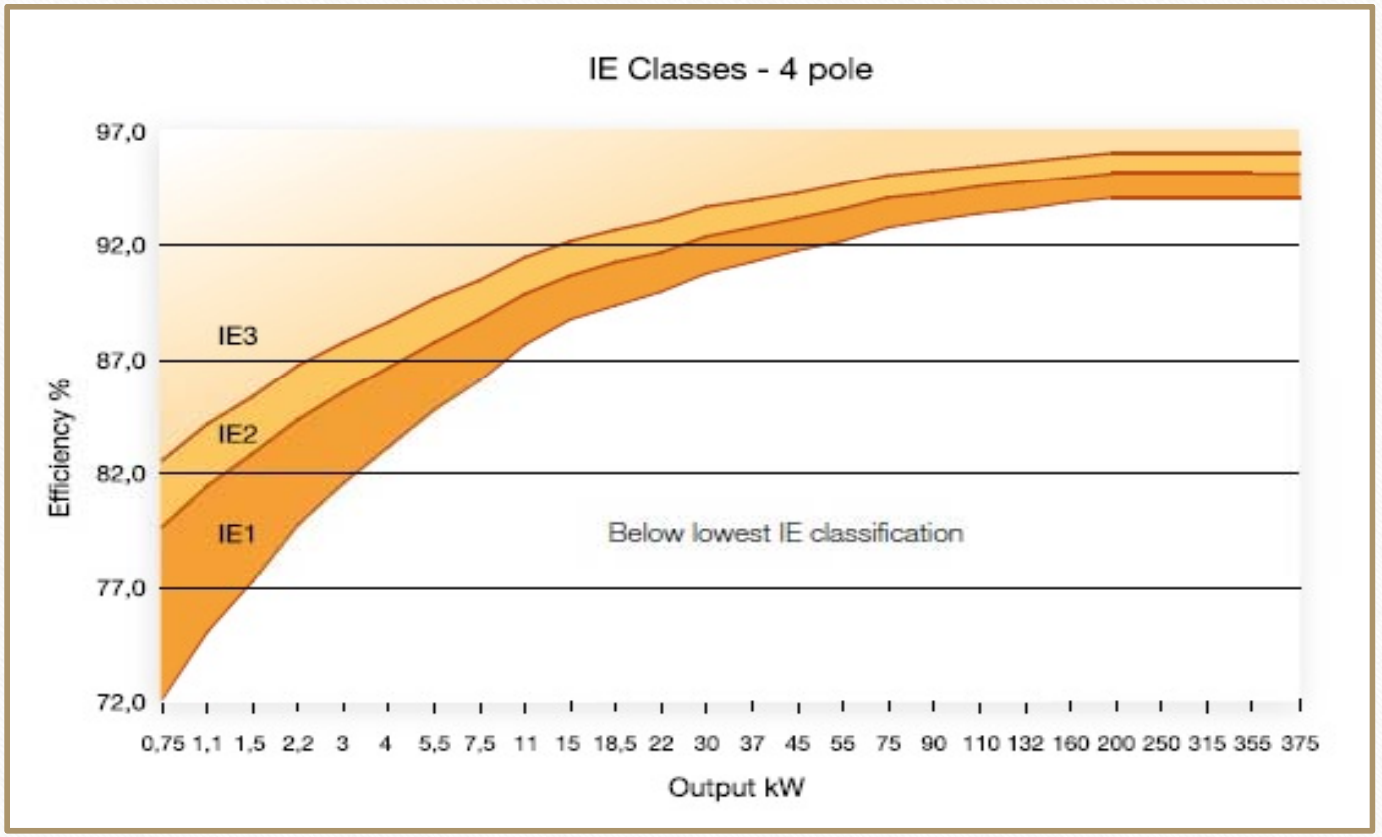
Engine Efficiency and Costs

Load (kW)	Annual hours	Cost with 105 kW Engine	Cost with 55 kW Engine	Cost with 55 kW and 10 kW Engines
3	3000	$3,780	$3,690	$2,790
8	1750	$5,460	$4,900	$3,780
20	125	$850	$750	$750
30	125	$1,163	$1,050	$1,050
	Total	$11,253	$10,390	$8,370
			Savings	$2,883

A.C. Electrical Systems

- Most vessels are using old technology motors, pumps, fans and compressors.
- Most use old technology switching that often draws current even when devices are not doing work.
- Many on-board devices consume energy when not actually working. For example, an AC-powered hydraulic steering motor on a tender was drawing 1 kW when not moving the rudder.

Motor Efficiency



http://ngelmuelektro.wordpress.com/2011/06/24/motor-efficiency

Motor Efficiency and Savings

88% Standard Efficient Motor - 15 HP Circulating Pump

Input Power: 17.04 HP

Cost for 2000 hrs/yr (23%) operation: $8,898

92.4% Premium Efficient Motor - 15 HP Circulating Pump

Input Power: 16.23 HP

Cost for 2000 hrs/yr (23%) operation: $8,475

Annual Savings: $423/yr

Initial Cost: $1,600

Motor Life: 10 yrs

Annual ROI: 16.4%

Payback: 3.78 yrs

10 yr Motor Life Cycle cost

Note: Of motor lifetime cost, approx. 97% is energy.

Motor Efficiency and Savings

68% Standard Efficient Motor - 1 HP Circulating Pump

Input Power: 1.47 HP
Cost for 2000 hrs/yr (23%) operation: $768
Purchase Price :$321

82.5% Premium Efficient Motor - 1 HP Circulating Pump

Input Power: 1.21 HP
Cost for 2000 hrs/yr (23%) operation: $626
Purchase Price: $446

Annual Savings: $141/yr
Cost Difference: $125
Motor Life: 10 yrs
Annual ROI: 102.7%
Payback: .89 yrs

http://www.baldor.com/products/

MOTORS CONTROL

Motor Variable Frequency Drives (VFD)

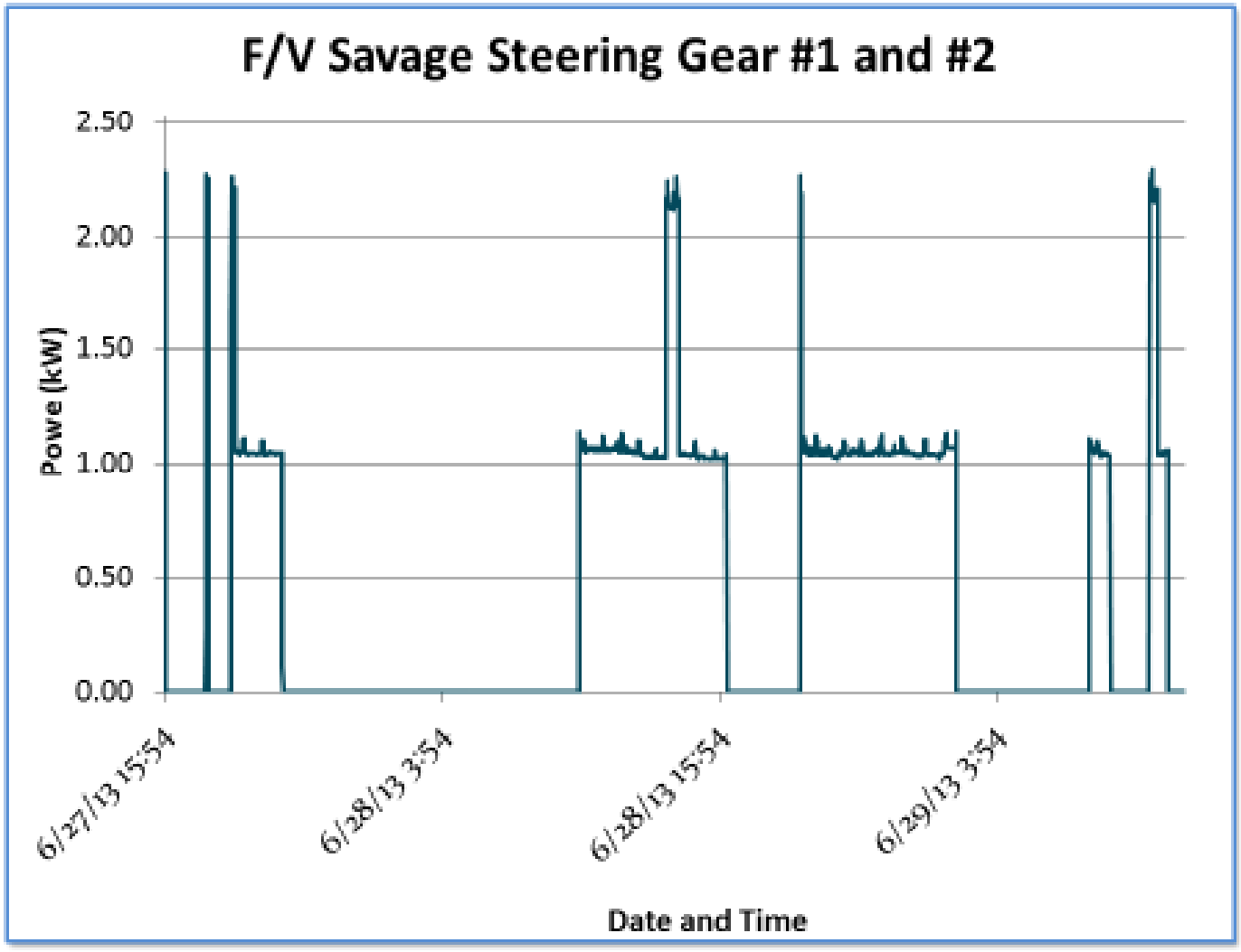
Steering Gear, Fans, Pumps, Winches

~~VFD for S.W. Cooling Pump~~

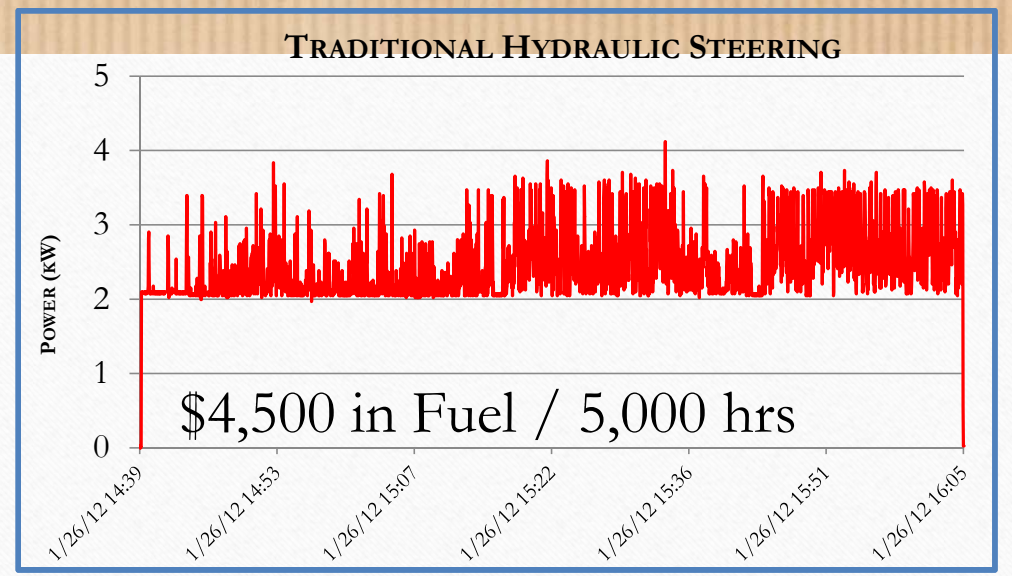
Reduce Centrifugal Pump Speed by ***½***

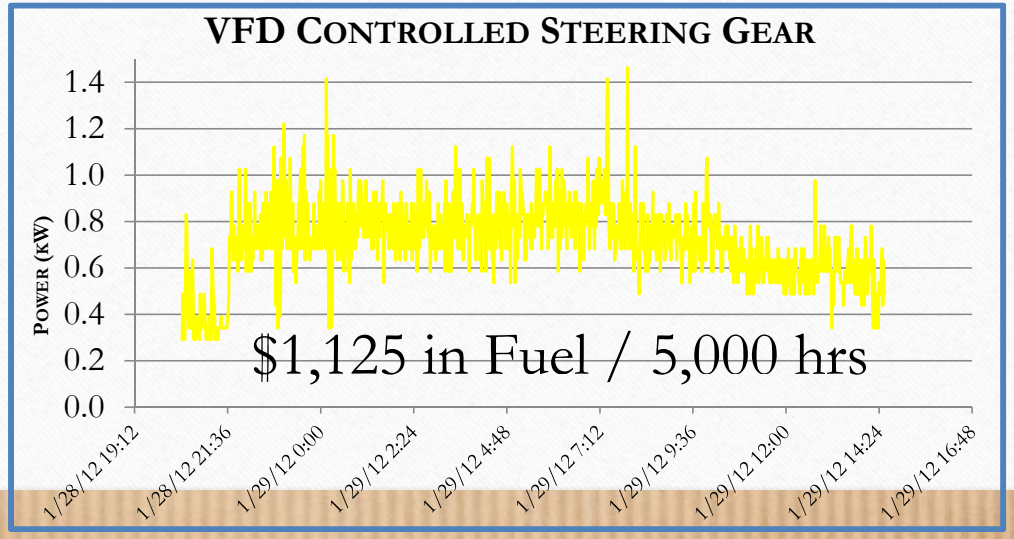
=

Power and Fuel Consumption reduced to ***1/8***


F/V Savage Steering Gear #1 and #2
2.50
2.00
1.50
1.00
0.50
0.00
Powe (kW)
6/27/13 15:54
6/28/13 3:54
6/28/13 15:54
6/29/13 3:54
Date and Time

VFD on Hydraulic Steering
70% reduction in Energy Usage





AC Electrical Systems

Electrical equipment including motors also have inherent inefficiencies. Pumps, motors and fans typically lose 5-40% energy to heat.

Electrical motors tend to be more efficient when operating at full rated output but are only 50-70% efficient when run at lower settings.

IE3 grade motors are 80-95% efficient.

Each electrical device has a nameplate or other indicator of nominal amperage draw.

Many electronic devices like radios and radars have a full-power demand and a much lower standby rating.

Induction motors have large start-up surge demand, commonly 6X as much as when running. Start-up surge has to be taken into account when sizing generator capacity.

Over a 10-year working life of an electric motor, about 93% of total cost is energy, the remaining 7% is purchase price and installation.

AC Electrical Systems

Energy Conservation Measures

- Right size generators to match the load. A second, small unit may be more efficient than using a big set in an under-loaded application, and engine life would be increased.
- When replacing motors, pumps, fans, etc. select "premium efficiency" models. For lights, tools and appliances look for the Energy Star certified label.
- Install variable frequency drive (VFD) controllers on equipment that respond to varying demand.

AC Electrical Systems

More ACMs

- Heat living spaces and domestic water with engine heat from engine cooling circuit.
- Use LED lighting wherever feasible. Turn off lights and other small power users when not needed.
- Substitute a true sine wave inverter for generator for "hotel power" and other light loads.
- Use shore power if lights, pumps, compressors or other heavy demand units are needed at dockside.

HIGH EFFICIENCY LIGHTING

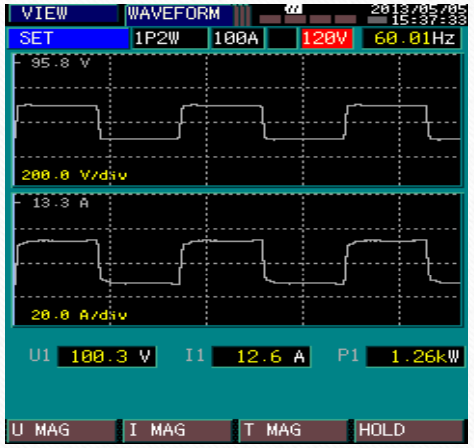
Initial Cost	$63,519
First Year Savings	$36,866
Payback Period (yrs)	1.7
ROI	62%
Net Present Value (10 yr)	$340,549
CO_2 Savings (MT)	117.4
Energy Savings (kWh)	213,962
Fuel Savings (Gal)	8,999

- Fluorescent Bulbs and Ballast
  - T12 Bulbs and Ballast phased out
  - Match Ballast to Bulbs
  - Specs for Bulbs and Ballast
- LED
  - New Technology
  - Life and Lumen output improved
  - Cost decreasing
  - Ensure quality LED used
  - Thermal Management of LED

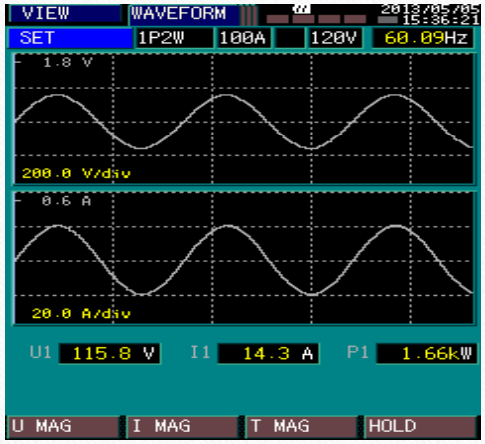
A/C Power from Inverters

- **Square Wave**
  - Issues with sensitive gear
  - Increases energy consumption
  - Lowest Cost
- **Modified Wave**
  - Less equipment sensitive
  - Better efficiency
  - Modest cost
- **True Sine Wave**
  - No issues with sensitive gear
  - Same or better than shore power
  - Best efficiency for gear
  - Highest Cost

Efficiency and impact on cost example to follow in next section.



Square Wave Inverter



Shore Power

Inverter Efficiency

Comparison: : Fuel cost for 1,000 Watt (1 kW) load for 1,000 hrs being charged by alternator on engine

Older 80% efficient Inverter

DC Input Power : 1,250 Watts
Engine Power (Alternator Efficiency 50%): 2,500 Watts
Total Efficiency: 40%
$/kWh fuel cost with engine at $0.40kWh = **$1.00 kWh**
Total Fuel Cost: $1,000

New 95% efficient inverter:

DC Input Power: 1,052Watts
Engine Power (Alternator Efficiency 70%): 1,502 Watts
Total Efficiency: 66%
$/kWh cost with engine at $0.40kWh = **$0.60 kWh**
Total Fuel Cost: $600

Low Loaded diesel Genset:

$.90/kWh and Up plus Maintenance ($1.50/hr to $2.25/hr): **$2.40.kWh**
Total Fuel and Maintenance = $2,400 to $3,150

AC Electrical Systems: Generation and Load

Diesel Generators
Inverters
Loads:
- Motors
- Lights
- Heaters

Take home messages:

- Size generators for actual load. Bigger is not better.
- Run gensets only when needed, under adequate load.
- True sine wave inverter. TSW 20% > than MSW
- Select premium efficiency motors IE3 = 3-21% > IE1
- Modern controllers – variable frequency drive
- Use energy efficient lighting.
- Use most efficient heating, which may not be electric.

Questions?

Terry Johnson

University of Alaska Sea Grant

Marine Advisory Program

907-274-9695 terry.johnson@alaska.edu

http://seagrant.uaf.edu/map/fisheries/fishing-vessel-energy-audit/

Dan Falvey, ALFA
myriadfisheries@gmail.com

Julie Decker, AFDF
jdecker@afdf.org

Sea Grant Alaska

AFDF