


The Department of the Navy's Research Development and Acquisition Community Efforts to Achieve the Navy's Energy Goals

Enabling Energy Security

Strategic Directions




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March 2011



SECNAV Energy Goals

Energy Efficient Acquisition	Evaluation of energy factors will be mandatory when awarding contracts for systems and buildings ♦ ♦ ♦
Sail the "Great Green Fleet"	DON will demonstrate a Green Strike Group in local operations by 2012 and sail it by 2016 ♦ ♦ ♦
Reduce Non-Tactical Petroleum Use	By 2015, DON will reduce petroleum use in the commercial fleet by 50%
Increase Alternative Energy Ashore	By 2020, at least 50% of shore-based energy requirements will come from alternative sources; 50% of DON installations will be net-zero
Increase Alternative Energy Use DON-Wide	By 2020, 50% of total DON energy consumption will come from alternative sources ♦ ♦ ♦

♦ ♦ ♦ RD&A Implementation

Emissions Regulatory Requirements Impacting MSC

- **Nitrogen Oxide (NOx)**
  - **October 2008: IMO adopted new standards to control exhaust emissions from marine diesel engines under MARPOL Annex VI, Regulation 13**
  - **April 2010: EPA finalized emissions standards under the Clean Air Act for new marine diesel engines with per-cylinder displacement at or above 30 liters (Category 3 Engines)**

MARPOL Annex VI NO_x Emission Limits ($g\ kWh^{-1}$)

Tier	Ship Construction Date	Rated Engine Speed (crankshaft)		
		n < 130	130 < n < 2000	n > 2000
Tier I	Prior to 1 January 2011	17.0	$45*n^{-0.2}$	9.8
Tier II	1 January 2011 – 31 December 2015	14.4	$44*n^{-0.23}$	7.7
Tier III*	On or after 1 January 2016	3.4	$9*n^{-0.2}$	2.0

*Applies to Emission Control Areas (ECAs) only.

Emissions Regulatory Requirements Impacting MSC

- **Sulfur Oxide(SOx) and Particulate Matter (PM)**
  - MARPOL Annex VI Regulation 14 states that SO_x and PM emissions are to be controlled via limitations on fuel sulfur content in designated Emission Control Areas (ECAs).
  - EPA has established identical fuel sulfur limits to Regulation 14, but the California Air Resources Boards (CARB) has more stringent standards.
- **Greenhouse Gases (GHG)/Carbon Dioxide (CO^2)**
  - Currently no regulations are in place. IMO is pursuing the use of market-based instruments to address GHG emissions and will be using the Energy Efficiency Design Index as a GHG metric for new ships.
- **Carbon Monoxide (CO), Total Hydrocarbons (THC)**
  - MARPOL Annex VI does not establish limits for CO or THC; however EPA establishes emission standards for Category 3 engines.
  - EPA Tier II Emissions Limits: CO (5.0 g-kWh^{-1}); THC (2.0 g-kWh^{-1})

MARPOL ANNEX VI

Emission Control Area (Baltic and North Seas)

- 1 July 2010 1.00% max
- 1 January 2015 0.10% max

GLOBAL

- Prior to 1 January 2012 4.50% max
- 1 January 2012 3.50% max
- 1 January 2020 0.50% max

(reviewed in 2018, may be deferred to 2025)

Regulatory Requirements Impacting MSC

- US Legislation
  - North American ECA, Approved July 2009
    - Encompass US and Canada coastlines
    - ECA to extend 200 nautical miles from the territorial sea baseline
    - Comes into effect in 2012
  - California Air Resources Board (CARB), 1 July 2009
    - All ocean going vessels enroute to a CA port and within 24 nautical miles of the coastline to use low sulfur MGO
    - Low sulfur requirements for main engines as well as auxiliary engines and auxiliary boilers (main boilers excluded)
    - Requires the use of MGO max 1.5%
    - Effective 1 January 2012, MGO max 0.1% in main engine, auxiliary engines and auxiliary boilers
- EU Legislation
  - Directive 2005/33/EC, Effective 1 January 2010
    - Marine fuels used by inland waterway vessels and ships at berth for longer than 2 hours must not exceed max 0.1% sulfur
    - No MGO (DMA) > 0.1% sulfur to be marketed in the EU
    - F76 may not meet this specification

Energy Security (Defined for this discussion)

- Ensured availability of the amount of *affordable* energy to perform required missions (a goal)
- Two strategies contribute to achieving this.
  - Have multiple sources of energy
    - more than one supplier of a given fuel (not considered)
    - more than one type of fuel can be used
  - Minimize the amount of energy to perform required functions

Alternative Fuels

- Alternative Fuels delivered via existing logistical supply infrastructure.
- Alternative Fuels taken onboard, stored and treated using existing tankage, purifying and handling systems.

"Oil products, liquid at common temperatures and pressures, are easily handled and stored. They possess the highest energy content per volume of all practical fuels and per weight of all liquid fuels, imposing the smallest penalties for energy storage …"

from Schafer, A., H.D. Jacoby, J.B. Heywood and I.A. Waitz. "The Other Climate Threat: Transportation." American Scientist. Vol. 97. No. 6. November-December 2009. pp. 476-483.

USS Trenton

Photo # NH 63407 USS Trenton reefing top sails, circa the mid-1880s

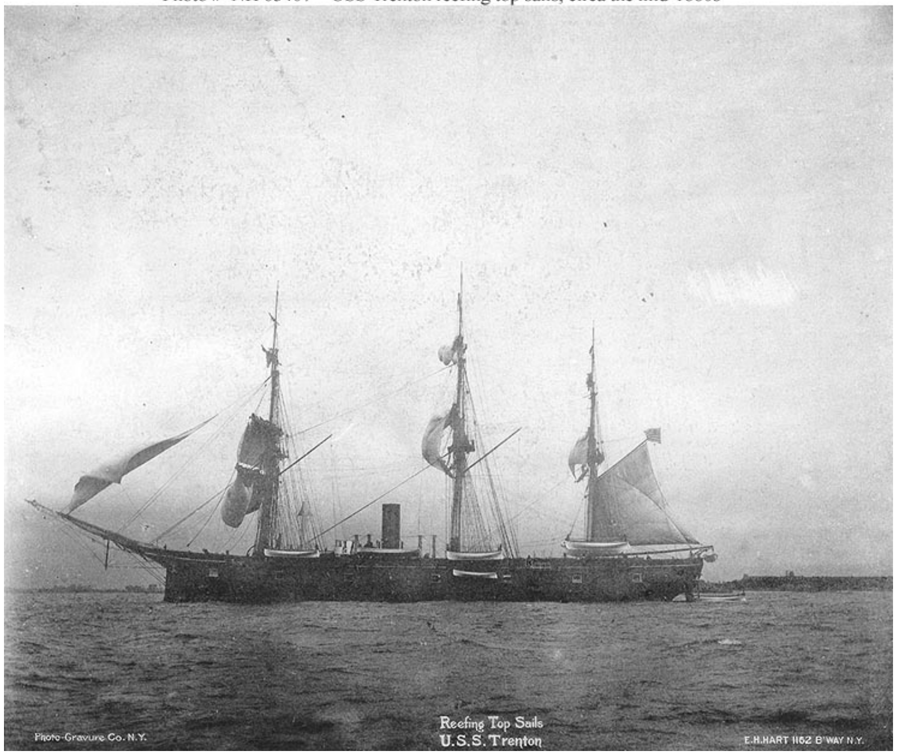
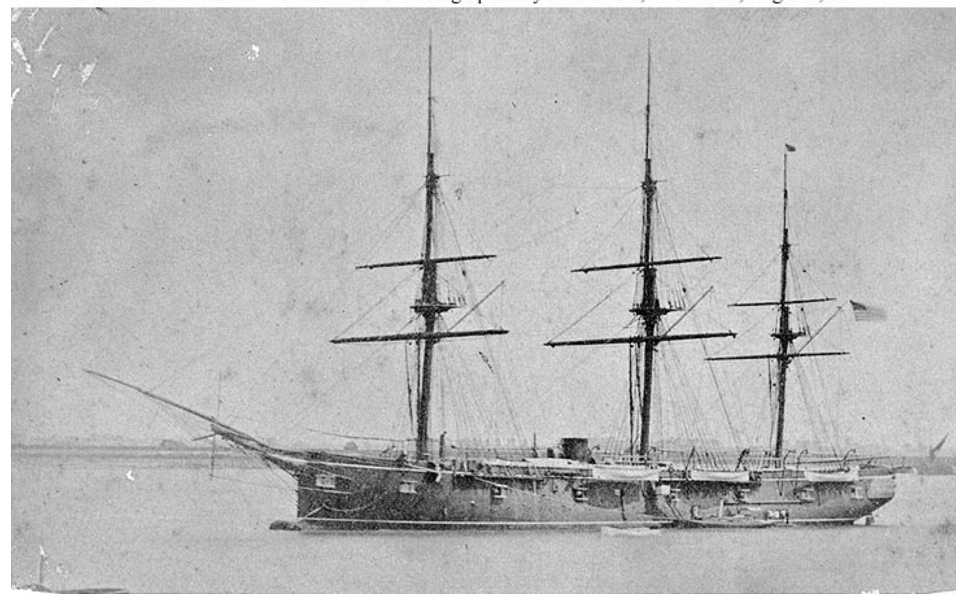


Photo # NH 97928 USS Trenton. Photographed by F.C. Gould, Gravesend, England, 1880



- Possessed multiple sources of energy for propulsion
    - Could be considered as having a hybrid drive
    - Wind energy and coal energy
- Required a capital investment in (and maintenance of) two distinct sets of propulsion equipment

Distribute Energy as Electricity

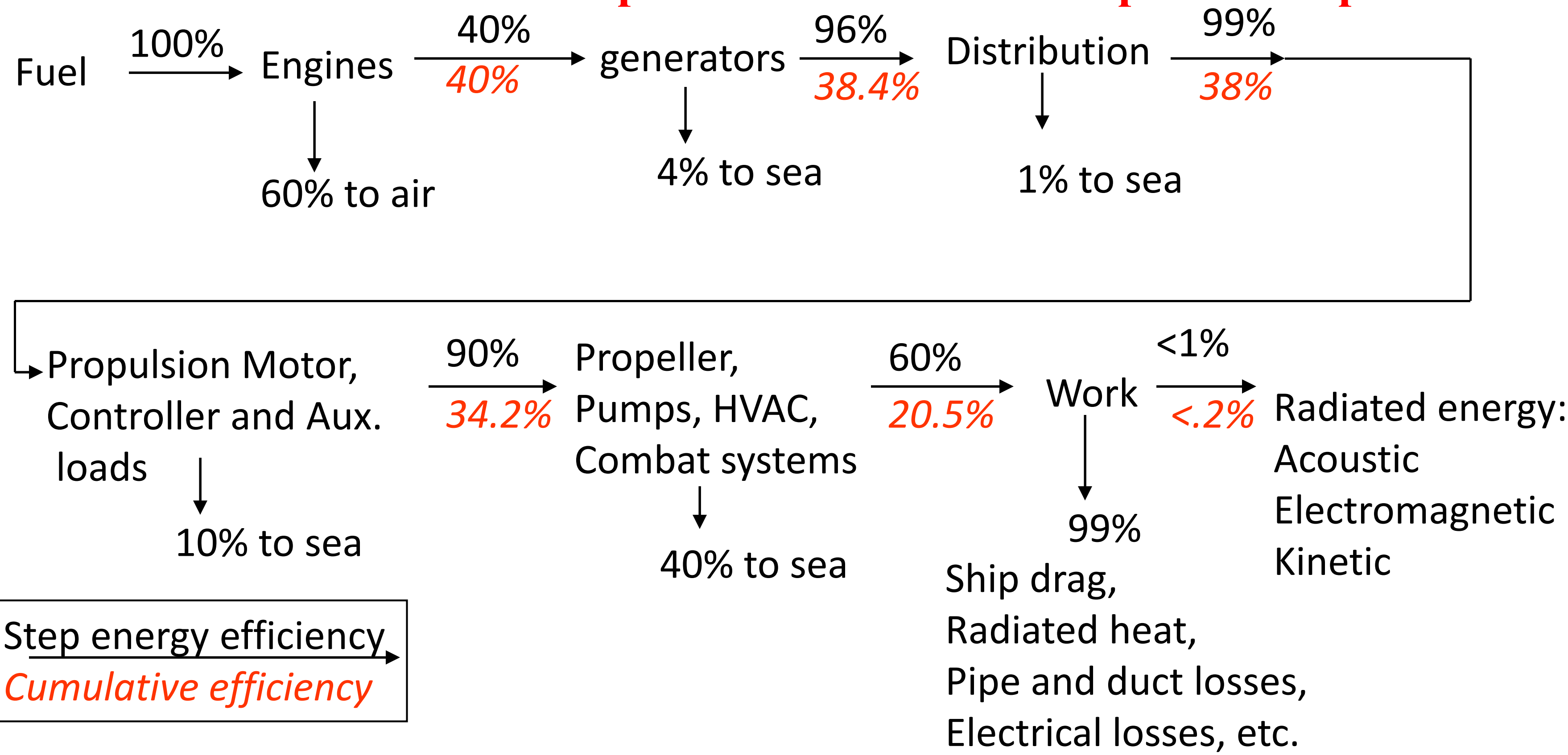
- **National Grid accepts energy from myriad sources.**
  - **The countless loads cannot distinguish sources.**
  - **This is the most economical means of distributing to loads from disparate sources.**
  - **Distribution infrastructure needn't be replaced if the sources are changed.**
- **On U.S. Navy ships this has been called Integrated Power Systems.**
- **Naval ships' power systems are SMART MicroGrids**
  - **Technical dialogue between national grid power engineers, Naval installations' power engineers and Naval ships' power engineers would be beneficial.**

This affordably enables using multiple sources of energy.

Notional Energy Flow for Electric Ship

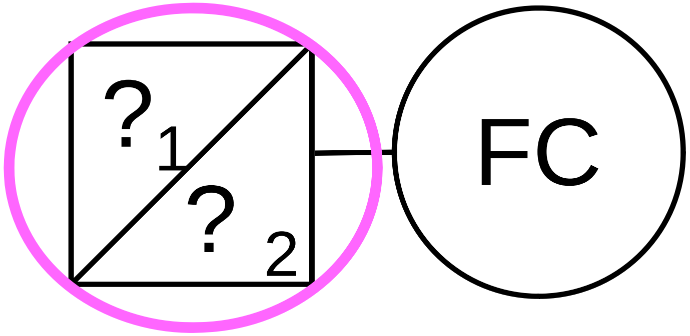
RDA Chief Systems Engineer

Caveat – this is based upon surface combatant operational profile.



- ~20% of fuel energy provides useful work so increasing efficiency at this level has a 5 fold impact relative to increasing engine efficiency
- Look for payoff in the low efficiency conversion steps
- 99+% of fuel energy is left behind in the water or air
- Added energy + inefficiency is required to carry away waste heat

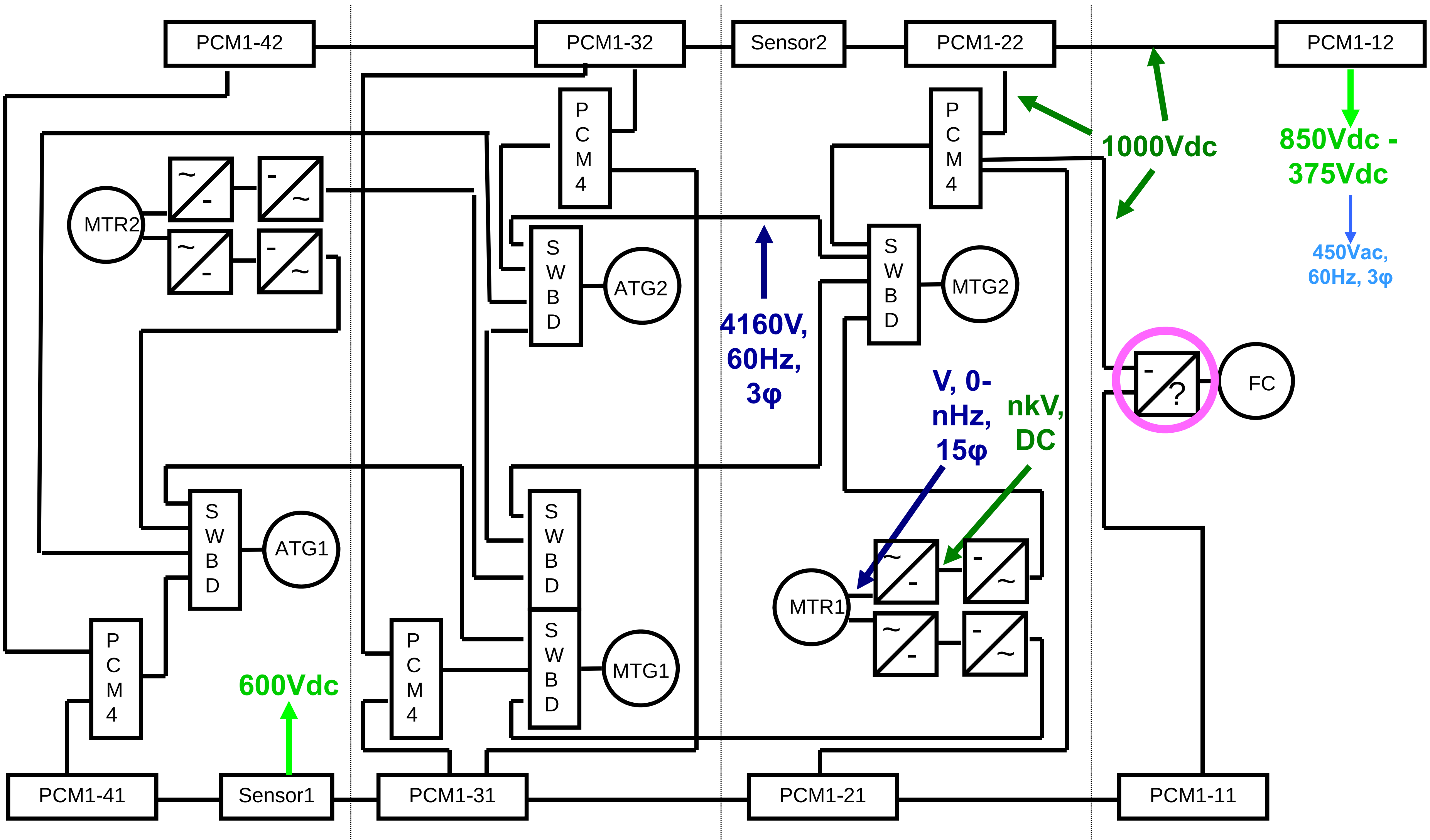
Notional Fuel Cell



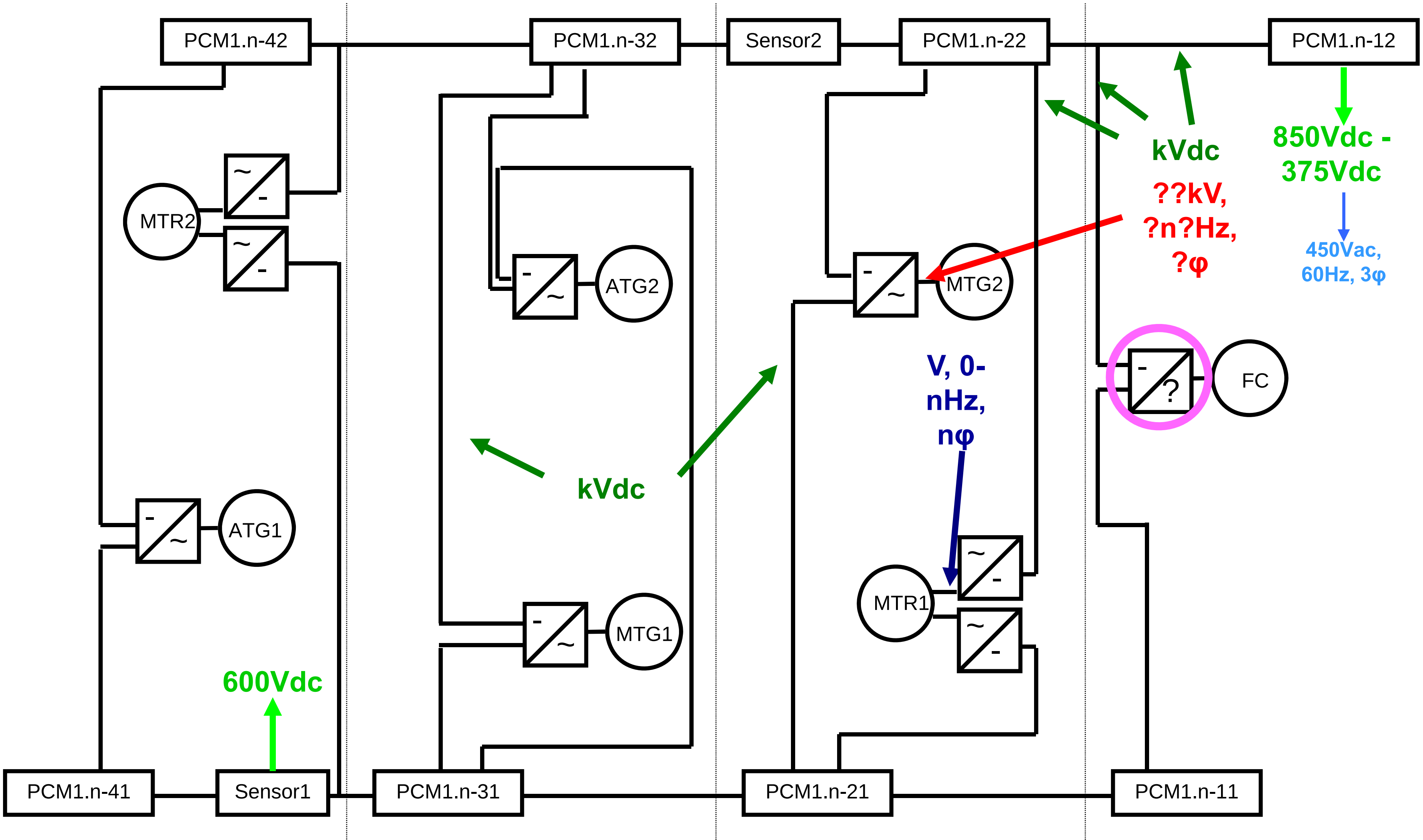
- “Front end” converter

AIM + IFTP IPS with DC-out Fuel Cell

RDA Chief Systems Engineer

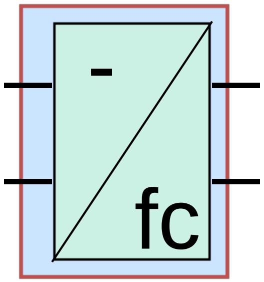


Unconstrained GTG + ATMtr + Modified 'HPDC' IFTP IPS with DC-out Fuel Cell



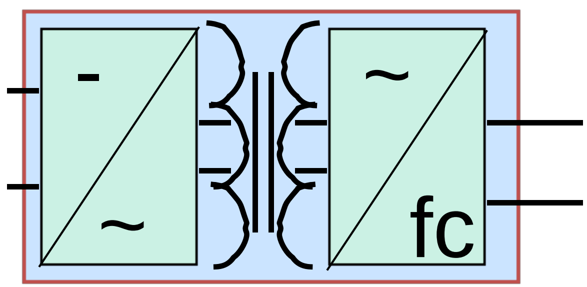
SiC Application – NEPS with Fuel Cell

kVdc



cell output

kVdc



cell output

Potential Application of Silicon Carbide Technology in Ship Systems!

Utilize Energy as Efficiently as Possible

- Accommodating load dynamics and source dynamics
  - Electric power systems can achieve this with energy storage
  - Faster, advanced power systems can do so within the space and weight constraints shipboard – MVAC to MVDC
- Inherently less lossy approaches to performing required functions
- 'Smart' manipulation of available energy
  - Requires investment in loads & power system

This affordably enables using less energy.

Two Approaches for Implementing Strategic Direction #2

- **Invest in load equipment, at the lower levels of the distribution system, the receiving end, that performs assigned missions using less energy, i.e. make them more energy efficient.**
  - o **Investment in S&T content of the equipment**
  - o **Investment in R&D (design guidance)**
- **Invest in improving the energy efficiency of the power system equipment where the loads aggregate, at the higher levels of the distribution system.**
  - o **Investment in S&T content of the equipment**
  - o **Investment in R&D (design guidance)**

More efficient loads require less capacity

More efficient power systems burn less fuel