



Central Cooling System Automation Upgrades

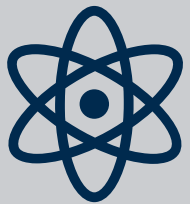
Demetres Armanes | September 2022



Recalling

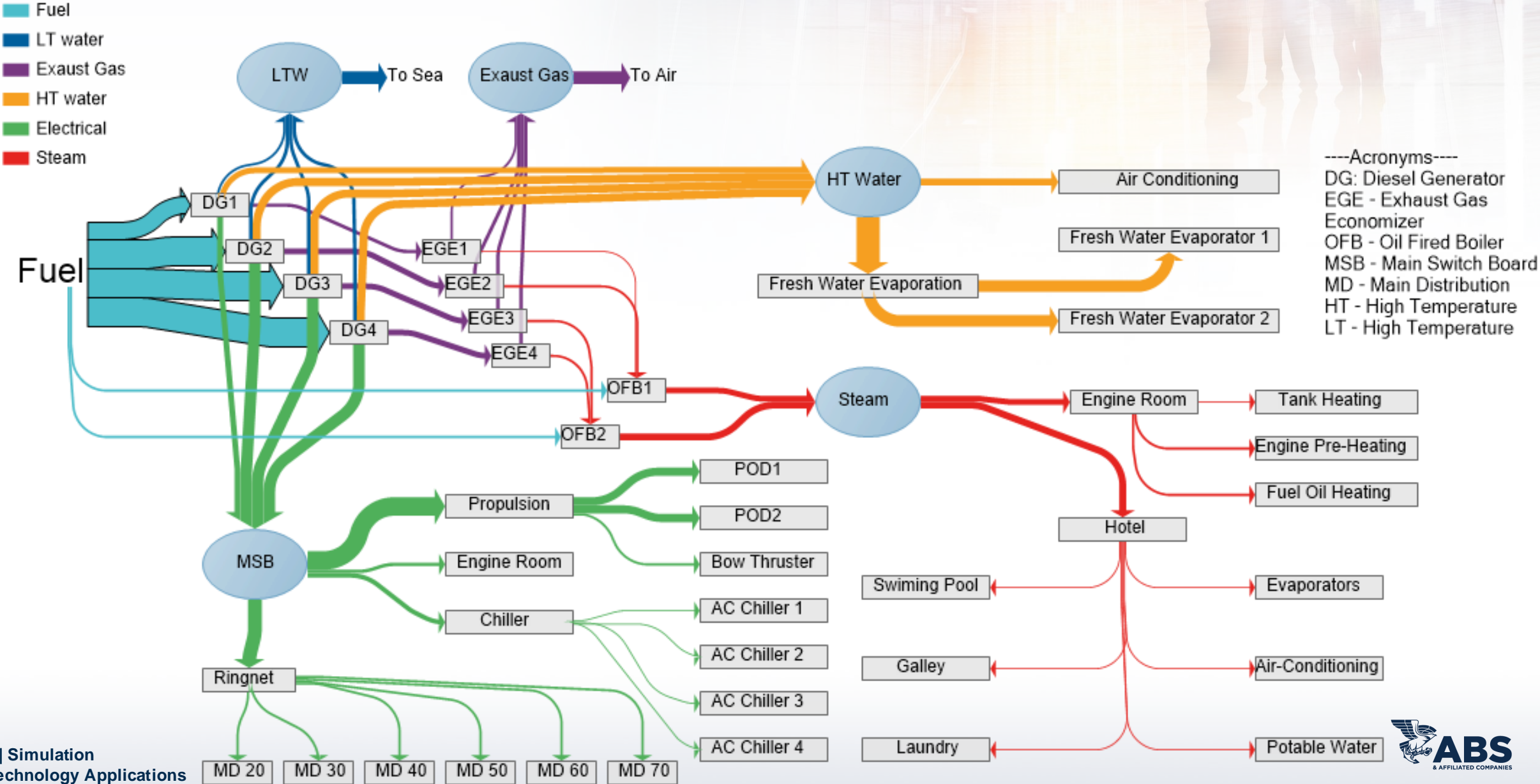


Energy is Power times Time

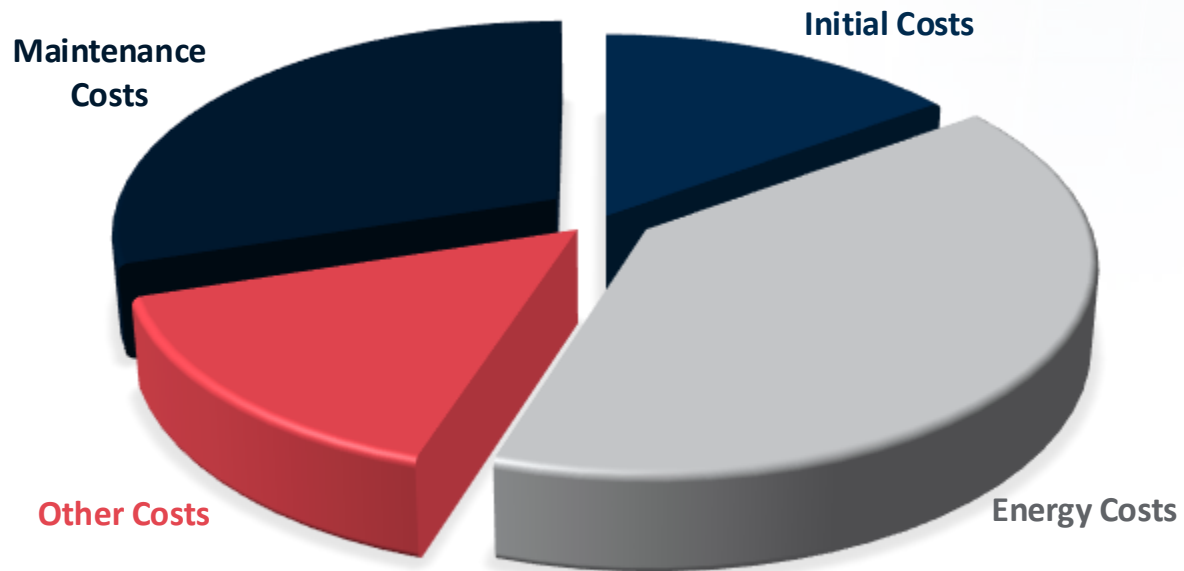


Energy can neither be created nor destroyed - only converted from one form of energy to another (Law of conservation of energy)

Energy Flows Mapping – Cruise Ship, Electric Propulsion



Typical Life Cycle Cost (LCC) of a Pumping System



C_{ic} = initial investment costs, purchase price (pump, system, pipe, auxiliary services)

C_e = energy costs (predicted cost for system operation, including pump driver, controls, and any auxiliary services)

C_{in} = installation and commissioning cost (including training)

C_o = operation costs (labor cost of normal system supervision)

C_s = down time costs (loss of production)

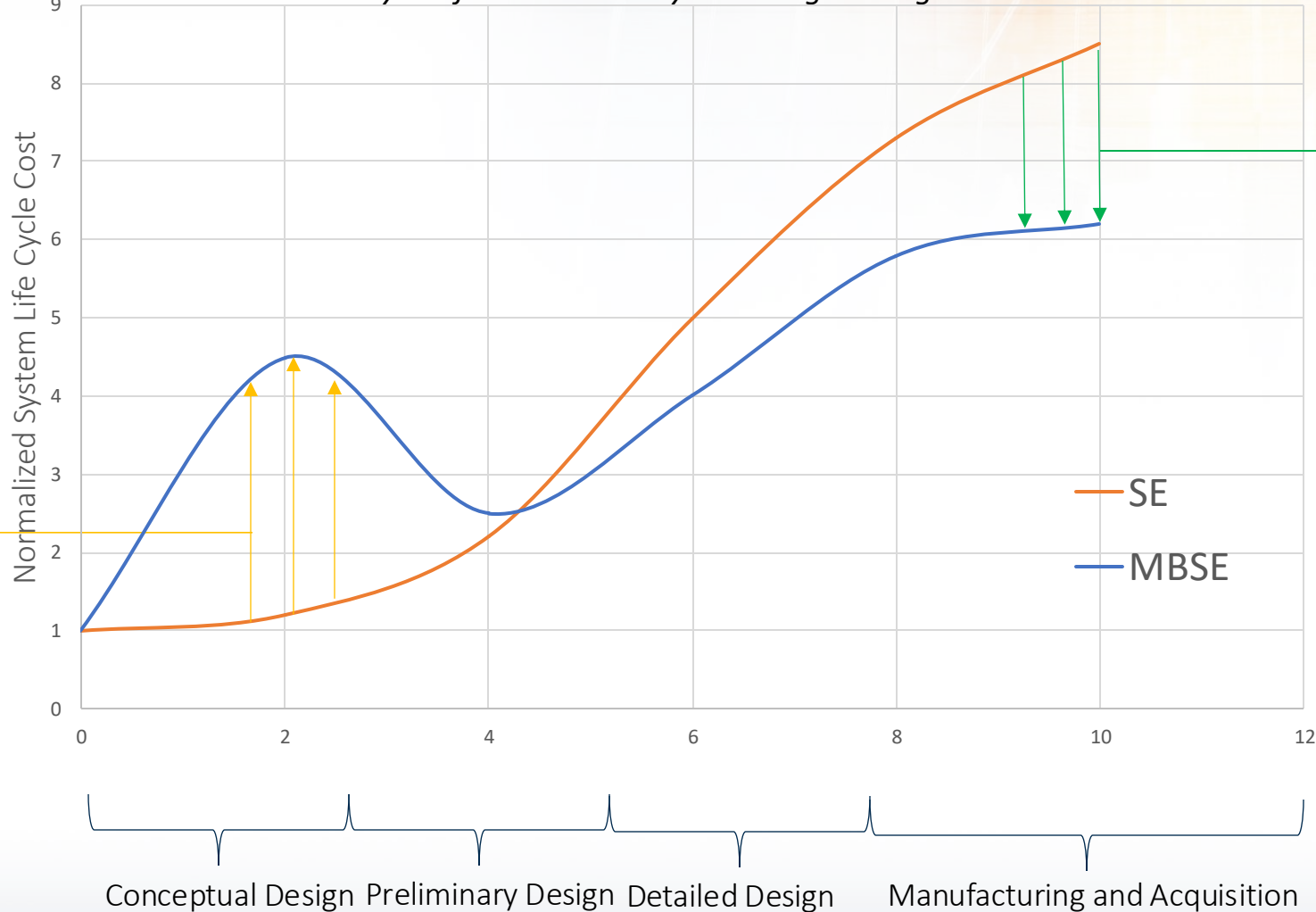
C_{env} = environmental costs (contamination from pumped liquid and auxiliary equipment)

C_d = decommissioning/disposal costs (including restoration of the local environment and disposal of auxiliary services).

C_m = maintenance and repair costs (routine and predicted repairs)

Initial Investment Costs and Model Based Systems Engineering (MBSE) ROI

Source: *Economic Analysis of Model Based Systems Engineering*



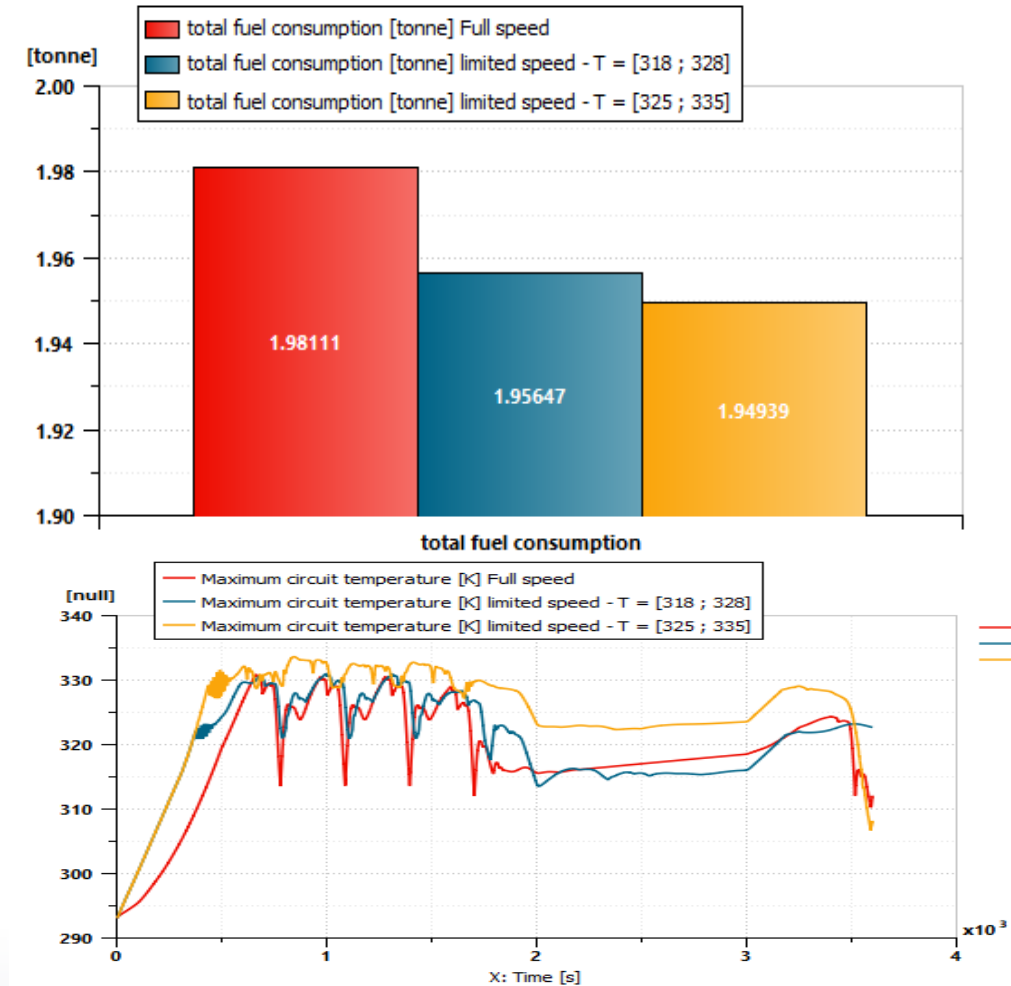
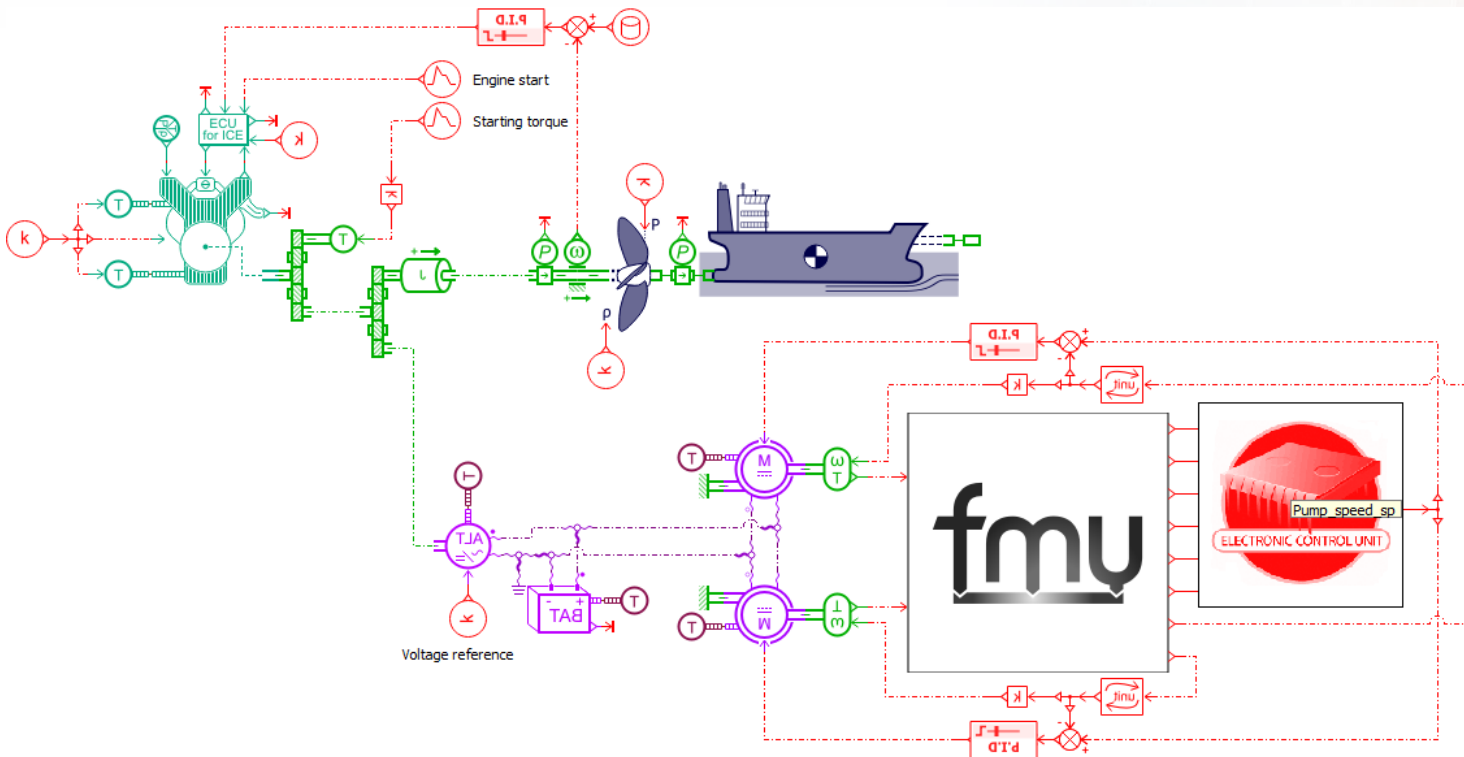
- ✓ Risk Reduction
- ✓ Improved communication
- ✓ Improved Energy costs
- ✓ Improved Maintenance costs
- ✓ Standard conformance and traceability
- ✓ Usage in supply chain
- ✓ Product line definition
- ✓ Reuse

Factors related to MBSE gains

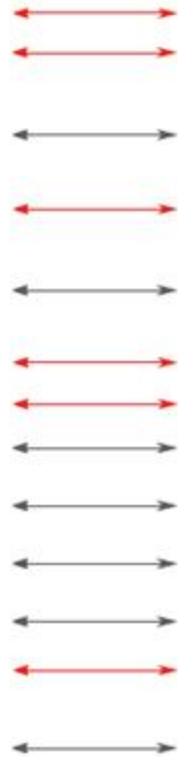
- Cost of Process Definition
- Infrastructure Cost
- Training Cost
- Model Development
- Model Verification
- Model Curation
- Configuration Management

Factors related to MBSE investment

Energy Costs and Model Based Systems Engineering (MBSE) ROI



VFD controllers' performance validation



HIL SCADA - active filter (switching).cpd

File Model Panel View Help

Panel Explorer

[UNLOCKED] [ACTIVE] - active filter (switching).cus

Active filter

Load Power [kW]

34.9 % Load THDi 3.6 % Source THDi

Enable Max output 100.0A Enable output li

Harmonic compensa 76.4 A Max output rea die

PF compensa Filter current RMS

136.6 kW Source P 0.963 Grid PF

Grid side harmonic measurement

Order	Value
1st	100.00 %
5th	0.05 %
7th	0.32 %
11th	0.28 %
13th	0.26 %
17th	0.40 %
19th	0.36 %
23rd	0.57 %
25th	0.45 %

Load-side harmonic measurement

Order	Value
1st	100.00 %
5th	32.89 %
7th	10.00 %
11th	6.56 %
13th	3.27 %
17th	2.52 %
19th	1.87 %
23rd	1.12 %
25th	1.07 %

Signals Scope

10ms Default

Is_a [92.99 A/div]

Is_a [83.48 A/div]

Is_a [83.48 A/div] Van [81.31 V/div]

Layout Vertical

Scope running... TRG

Model Settings

ACTIVE

Model Controls

- Sources
- Contactors
- Switching Blocks
- Output Controls
 - Analog Outputs
 - HIL 0
 - Digital Outputs
 - HIL 0

Message Log

```
[15:03:46] : [SCOPE] Scope started
[15:04:27] : [MACRO EXECUTOR] Executing 'Load Power [kW]' embedded macro script
[15:04:27] : [MACRO EXECUTOR] Macro execution finished.
```

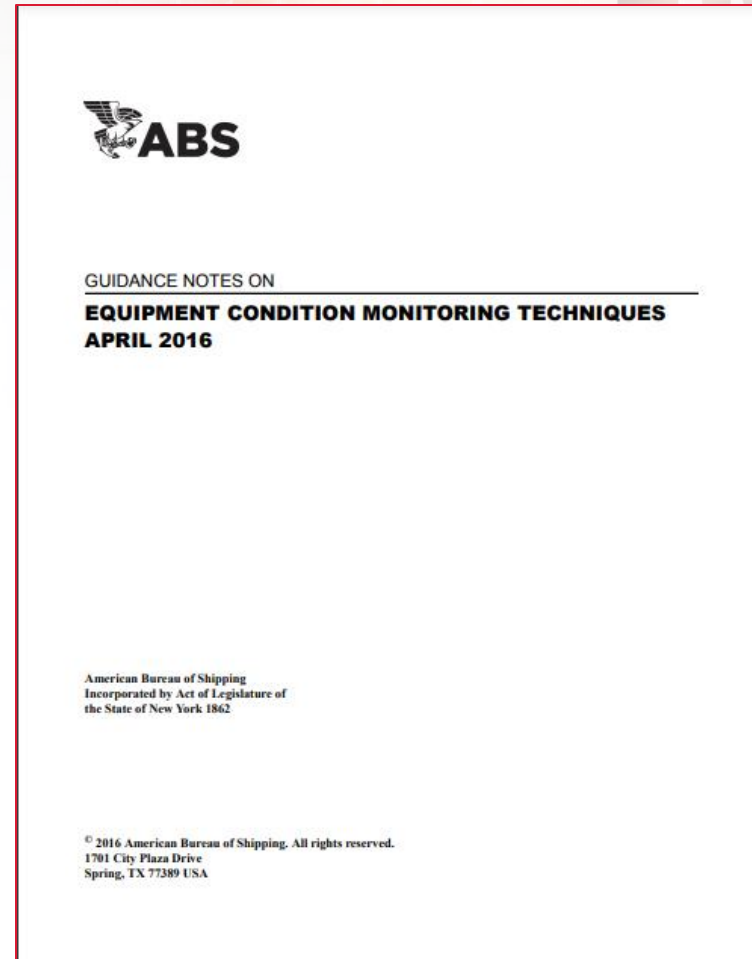
History View

<initial state>

TSO WER EXC CID SLD AO DTV PSU 00:00:00:02 VIRTUAL HIL MODE

Maintenance Costs and Model Based Systems Engineering (MBSE) ROI

- Energy Centered Maintenance (ECM) uses energy consumption excess or energy waste as the primary criterion for determining specific maintenance or repair needs. (Alshakhshir 31)
- Performance Trending as a CM technique for enrolment to the ABS Preventative Maintenance Plan (PMP) program



Glimpse of tomorrow - LNGC Eutropia powered by Wartsila-Hudong-ABS



Thank You

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