Energy Efficiency Measures in Existing Vessels : A critical overview

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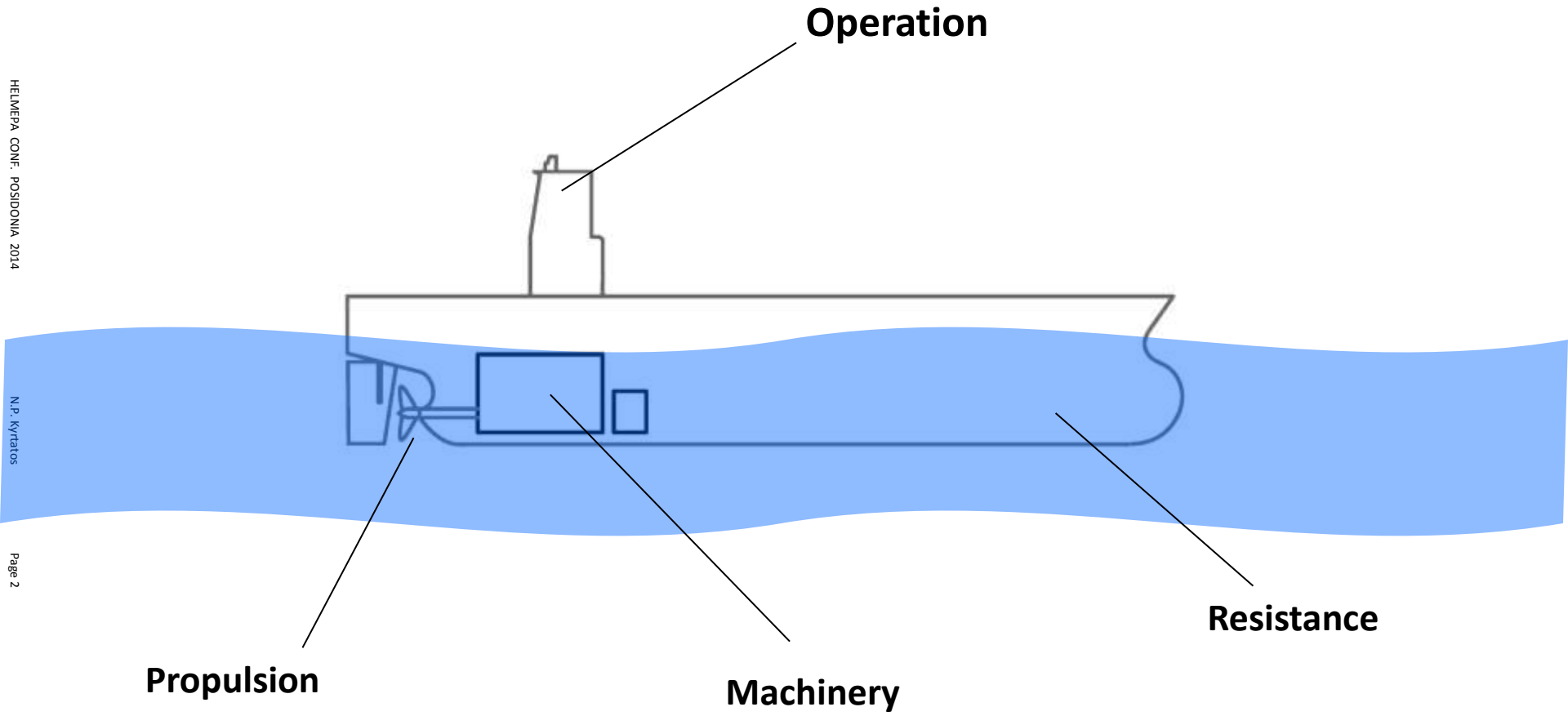
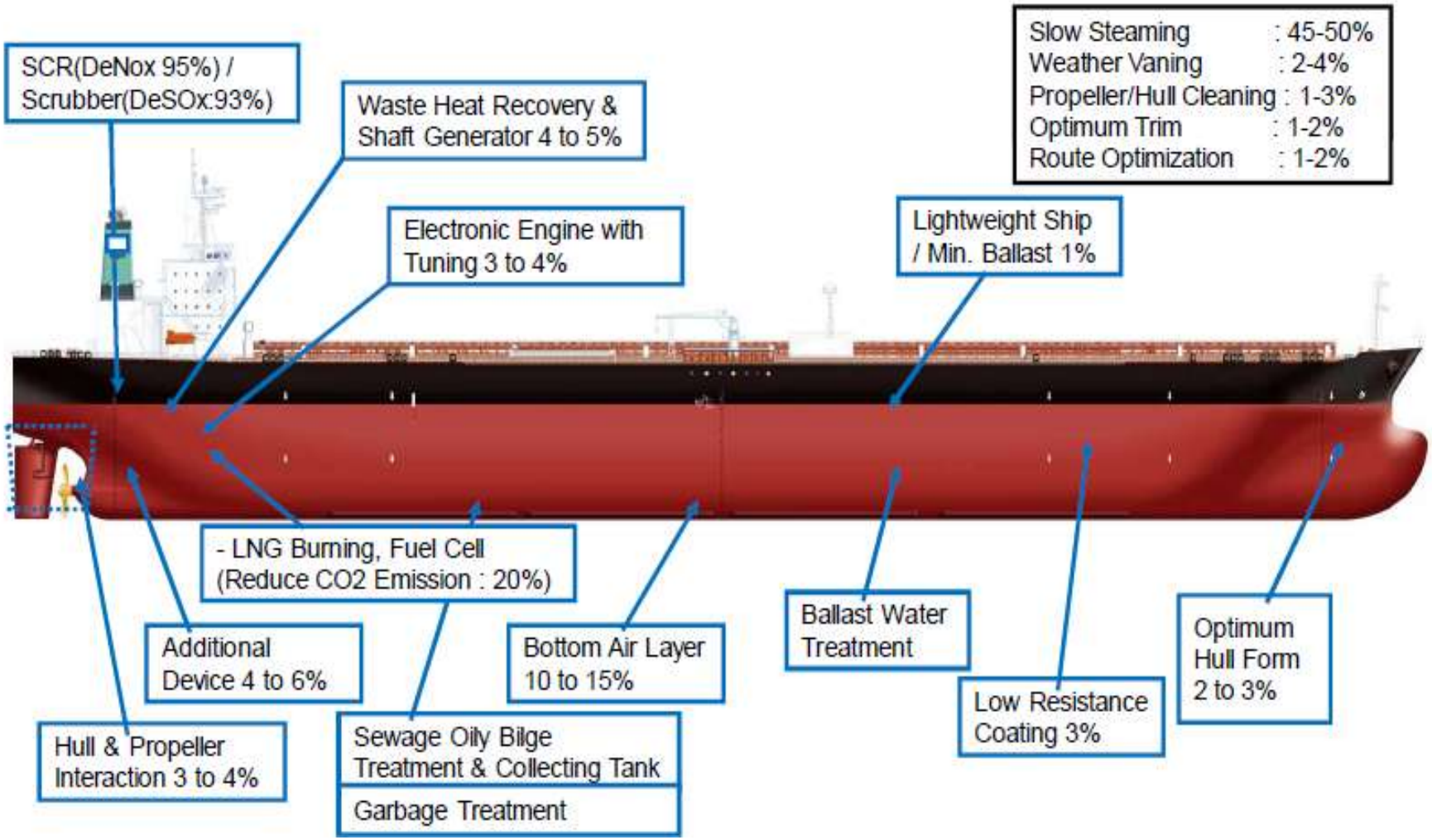

Operation
Propulsion
Machinery
Resistance

Fuel “saving” options: too many -too complex?



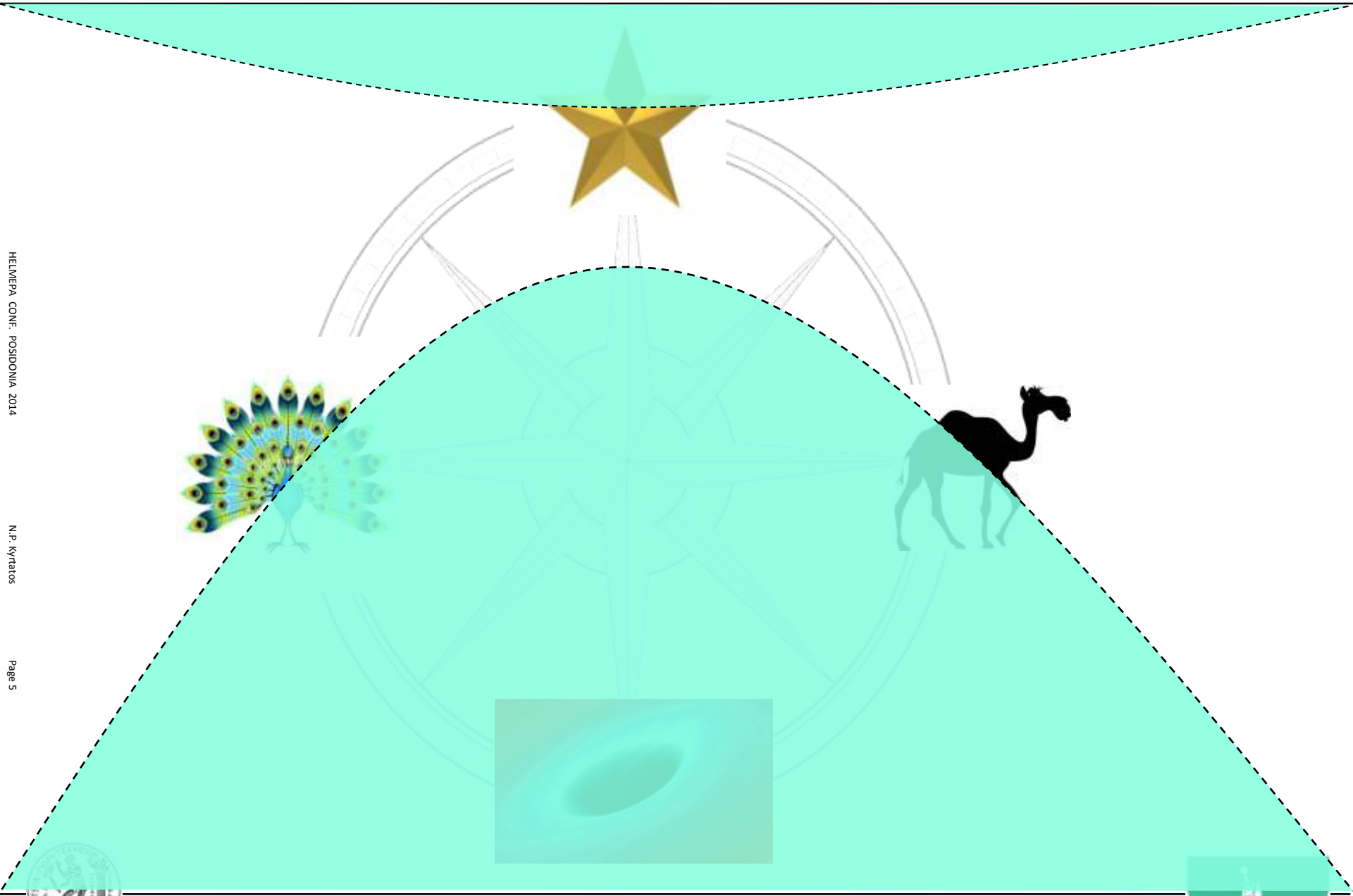
102%

Perpetuum mobile?

Measures for existing vessels

Resistance	Propulsion	Machinery	Operation
• Hull coatings / paints • Hull openings • Air streamlining • Bubble lubrication	• Flow augmentation – Pre-swirl ducts /fins – Propeller boss cap fins – Prop./ rudder bulb – Vane wheels –Improved rudder –……. •Propeller change	• Engine Tuning • Energy saving –Speed control pumps –Lighting –…. • Fuel Cells • Sails, Kites, Windmills… • Solar (Photovoltaics)	•Optimisation – Hull/propeller cleaning – Slow/fast steaming – Trim & ballast – WHR – Routeing –…… •Performance Assessment –Monitoring –Measurements –Fault diagnosis

Energy Efficiency Measures… taxonomy



“Reasonable” measures for existing vessels

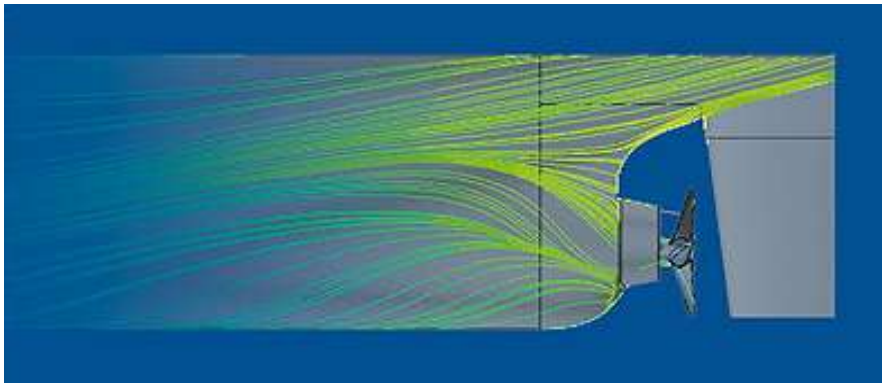
Resistance	Propulsion	Machinery	Operation
• Hull coatings / paints	• Flow augmentation	• Engine Tuning	• Optimisation • Performance Assessment

❑Applied Physical chemistry (+Black Magic)

- TBT –free anti-fouling
  - Biocidal
  - Foul release
- Hard coatings (+ hull cleaning)
- Innovative (microfibre, nanotech,…)
- Future (bio-mechanical)

➢Selection

➢Verification of performance (measurements?)

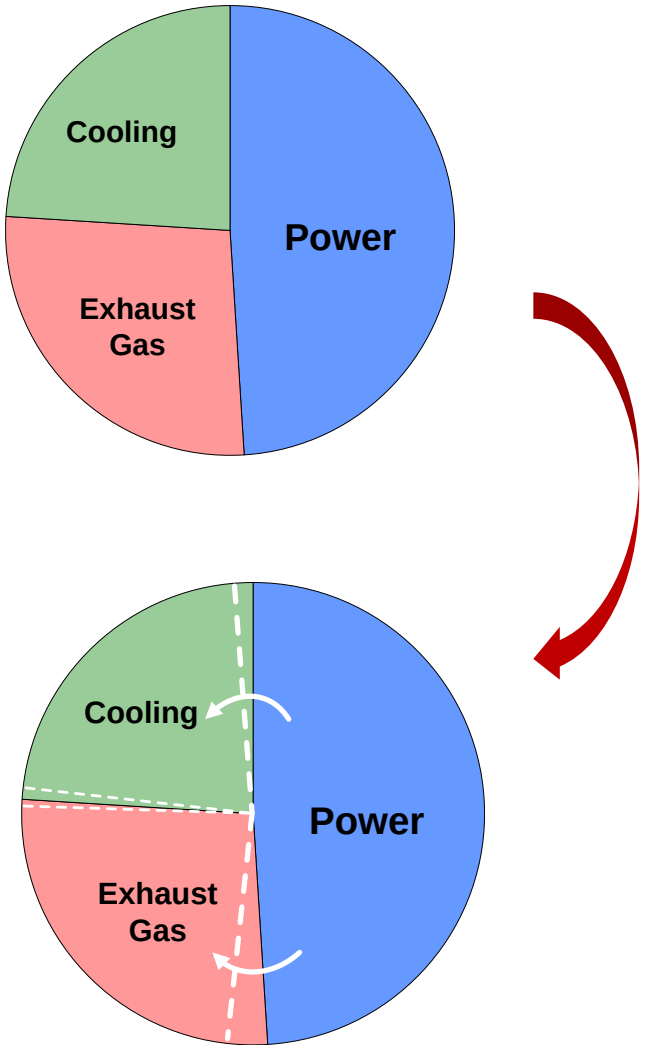


If initial design is poor, then worthwhile

If initial design is good then **not** advisable

- Check hydrodynamics!
  (r-o-t P.C. <60%)
- Selection
- Verification of performance (measurements?)

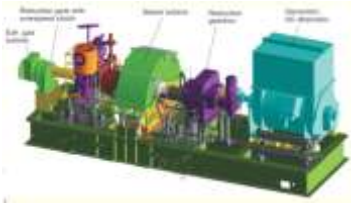
Reduce fuel consumption by Improving engine efficiency



- ❑ (Reduced heat rejection)

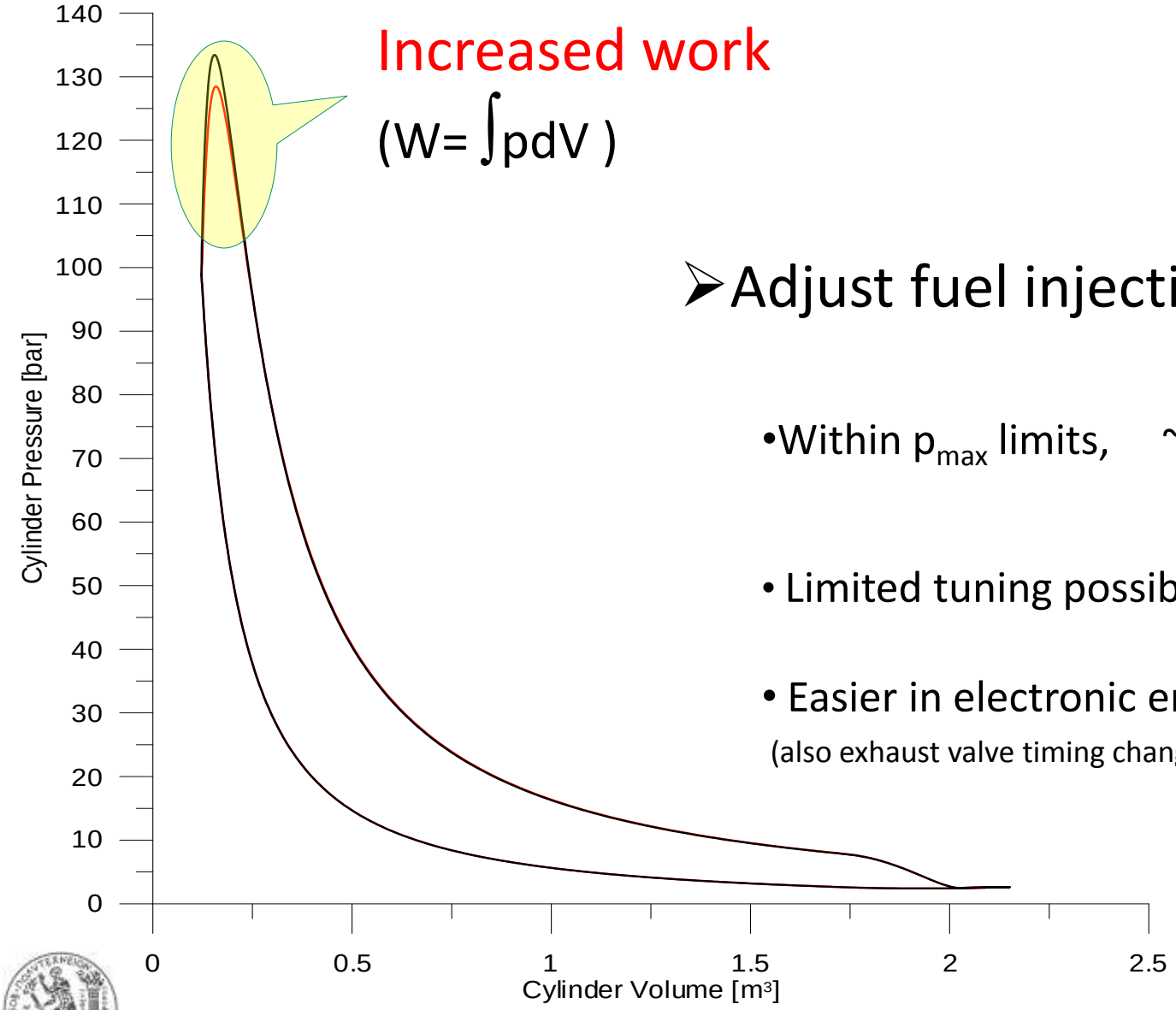
Practically not possible in existing engines

- ❑ Increased Waste heat recovery
  - Power production (steam)
  - Turbo-compounding (engine shaft)
  - PTO/PTI – Turboshaft



❑ *Extra capital investment required!*

- ❑ Increased work



Increased work

$(W = \int p dV)$

- Adjust fuel injection

- Within p_{max} limits, ~ (+5bar = -1gr/kWh)
- Limited tuning possibility! NOx limits.
- Easier in electronic engines

(also exhaust valve timing change –effective compression)

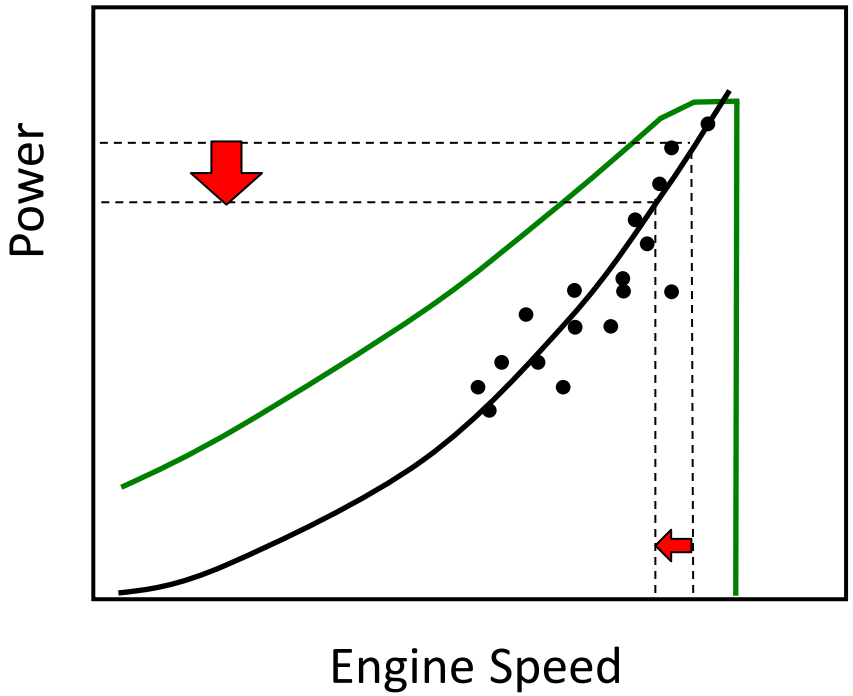
Slow steaming ⇒ lower Power demand ⇒ less Fuel

NB.1. ship capacity scales with speed, fuel cost scales with ~(speed)^3

NB.2. very low speeds w.r.t. safety

NB.3. propeller efficiency vs speed

NB.4. WHR capacity at low loads



If operation at lower load is long-term

Extra **efficiency** benefit, if engine is **re-optimized at part load**.

Increased air amount (Scavenging) and re-tuned P_{max} (easier with electronic engines)

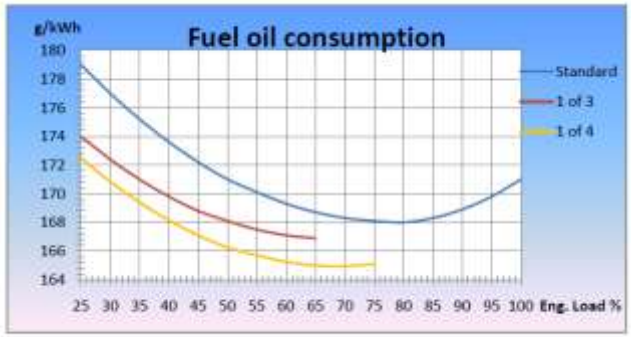
$P_{scav}\uparrow$ …then… $P_{comp}\uparrow$ …then… $P_{max}\uparrow$ …then… $\eta\uparrow$

➢ *Moderate Derating*

- Turbo changes (turbine nozzle/ compressor diffuser, trim)
- Retuning

➢ *Large Derating (rpm< 50%)*

- Turbo cut-off (if 2+ turbo's)
- Re-tuning
  - F. I. timing
  - E. V. timing
  - C.R.
- (Variable Geometry Turbocharger)



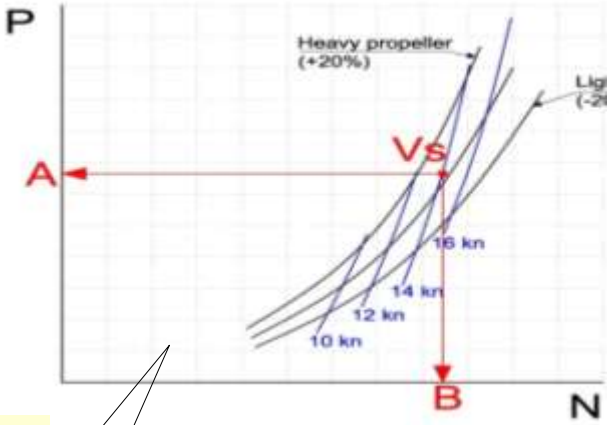
Fuel-oil consumption versus engine load

- *Part load η ↑*
- *Tradeoff NO_x / CO_2*
- *Part load temp reduction: Reliability ↑*
- *Tropical cond. heat load decreased*

any retrofits require proper analysis & design!

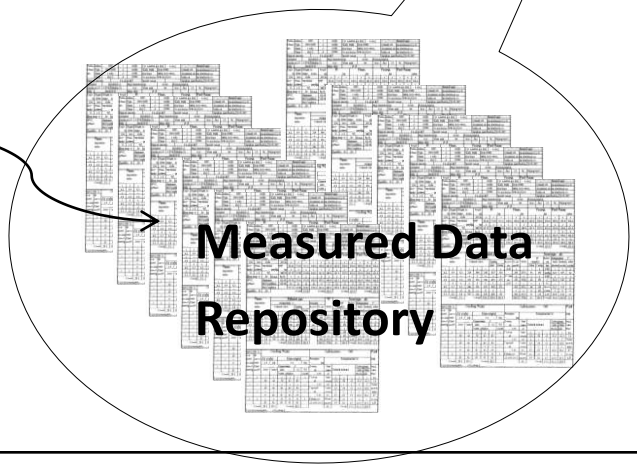
Operation

- Optimisation
  - Hull/propeller cleaning
  - Trim & ballast
  - Routeing
  - Energy usage and WHR
  - …



Statistics and models

onboard DAQsystems



Needs:

- *Process measured Data (lots!)*
- *Data analysis and statistics (tough!)*
- *Models of processes (tough!)*

Operation
• Performance Assessment

Retaining *or* ***improving performance***

of *EXISTING* PLANTS

Requires:

- Monitoring (= measure)
- Performance evaluation (= compare)

? *(Are these data reliable?)*

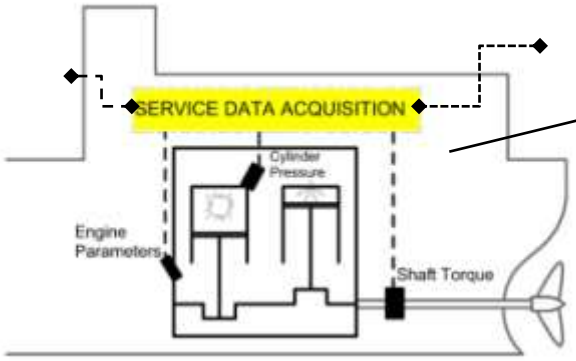
Reference Data

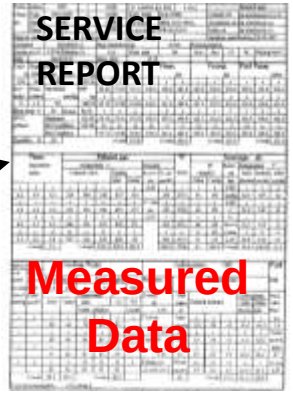
"Expected"

Compare

Performance Evaluation

"Observed"





? *(Are these data reliable?)*

•Data collection, recording, human errors, filtering, transfer, storing,…, retrieval, analysis, interpretation,.

To create reliable **reference** values, Use **Process models**

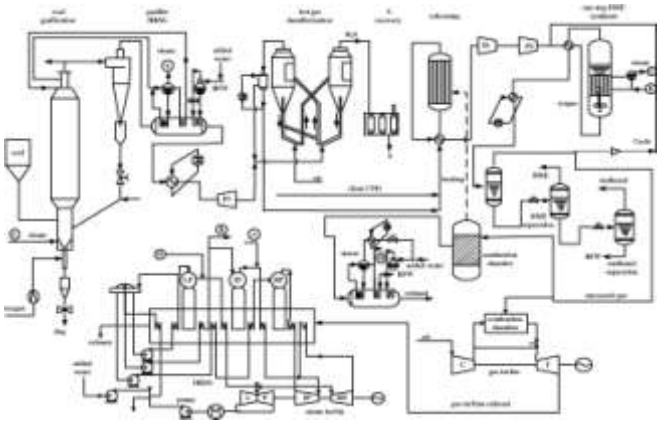
has been used in AEROSPACE

and PROCESS PLANTS

for 20 years

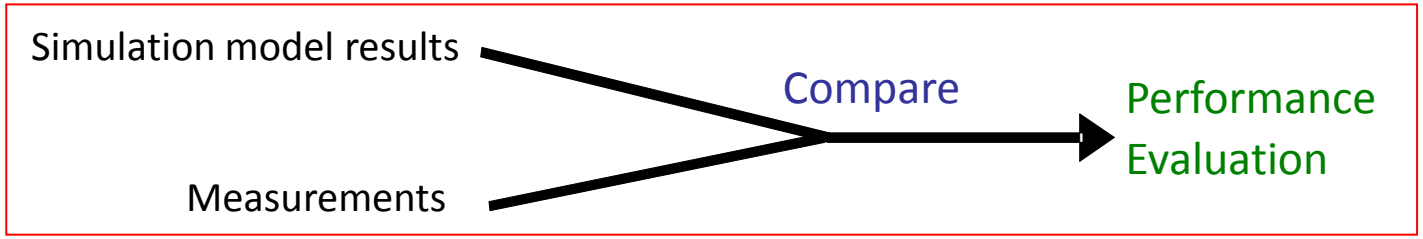
for PERFORMANCE EVALUATION,

FAULT DETECTION & DIAGNOSIS (**FDD**)



- generate "**expected**" values

  for the exact operating condition, as reference to compare with "measurements"



- Monitoring-DAQ systems: maintenance, calibration,… Sensor reliability, cost, redundancy…

For *complex processes*,

measure only parameters ***easy*** to measure <u>accurately & reliably</u>
(e.g. Temperatures, low Pressures, RPM…) possibly with sensor redundancy!

and then use a ***process model,*** fed with these high fidelity measurements,

➢**Compute** parameters **difficult** to measure reliably
(e.g. Power, Torque, Fuel Consumption, gas emissions..)

Virtual Sensors *start appearing in aerospace, automotive and process industries*

Marking of Energy Efficiency Measures for existing vessels

MEASURE / CRITERION	Advanced hull coating	Propeller Enhancement	Engine Tuning	Performance Assessment + Optimisation
Difficulty selection & decision	***	**	**	***
Difficulty application	*	**	**	*
Benefit/Cost	**	*	*	***

***	*HIGH*
**	*MEDIUM*
*	*LOW*

END OF PRESENTATION

END OF PRESENTATION

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