


IPIC 2023

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Enhancing Energy Efficiency and Dynamic Carbon Footprint Calculation at Container Terminals

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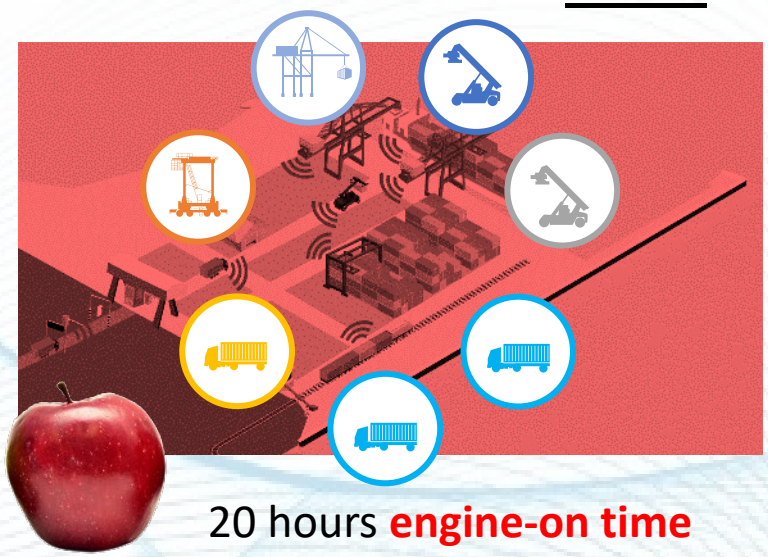
iTerminals 4.0

The TIC 4.0 concept - Example: Terminal Manager

Terminals have the same equipment types, with different definitions per brand



20 hours **engine-on time**

working time

Container locked

container moved

20 hours **"key on" time**

working time

Container locked & unlocked

container moved

20 hours **"man hours – driver"**

working time

Container from A to B

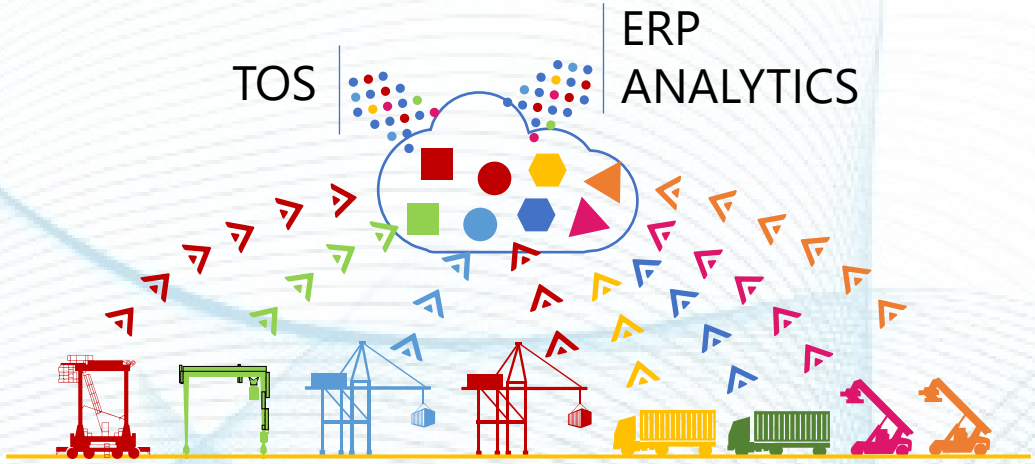
container moved

IF Data in a database is not the same, 1 on 1 comparison is NOT possible

What is TIC 4.0?

TIC4.0 is a project to define industry standards for ports and terminals

Enabling communication for all stakeholders in Ports & Terminals



Current situation

- Different Standards for every equipment provider, some might not be connected
- Difficult to compare results, since different measurement methods are used

TIC4.0 Implementation

Vision

- Single broadly accepted standard for Ports & Terminals operations
- Easy to compare results between equipment

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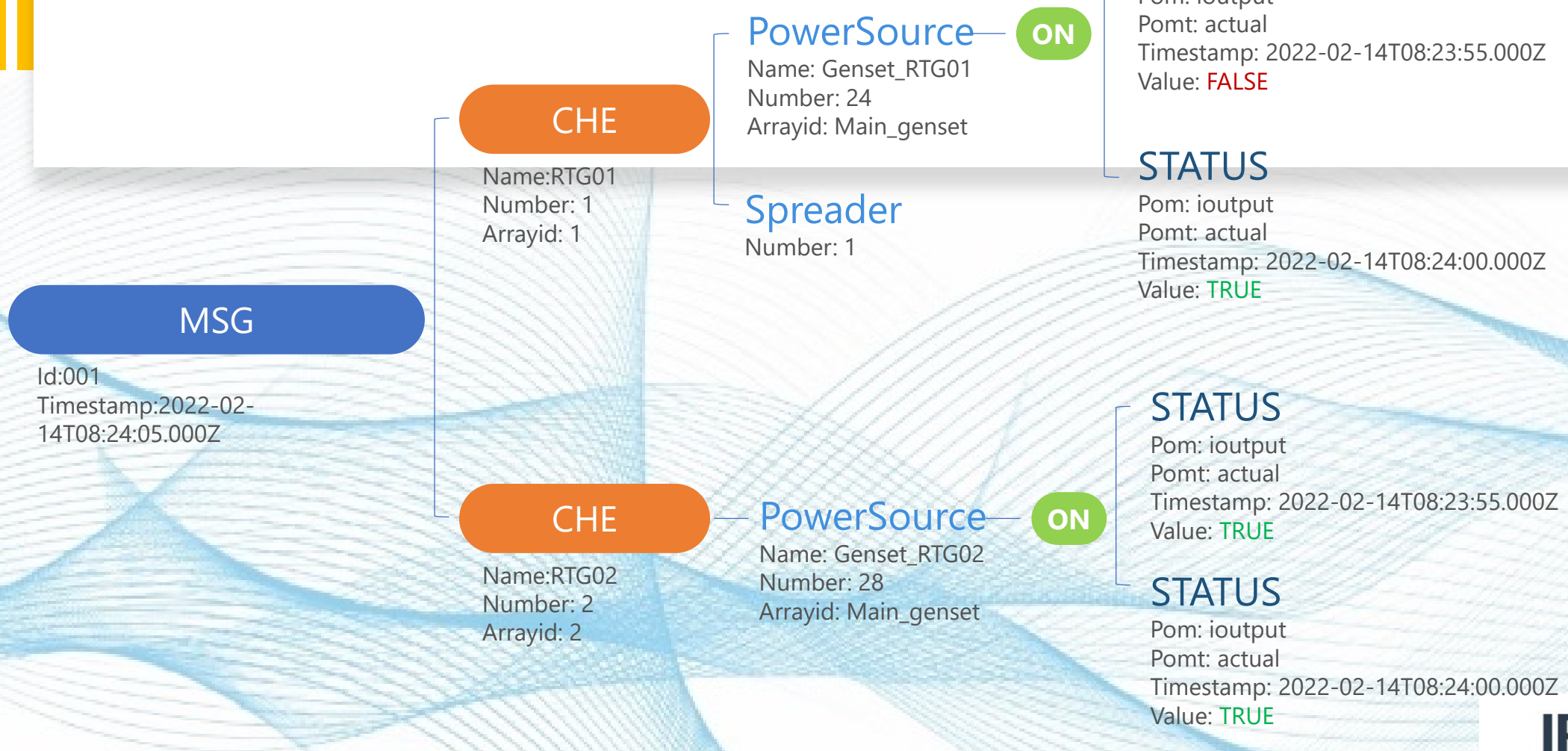
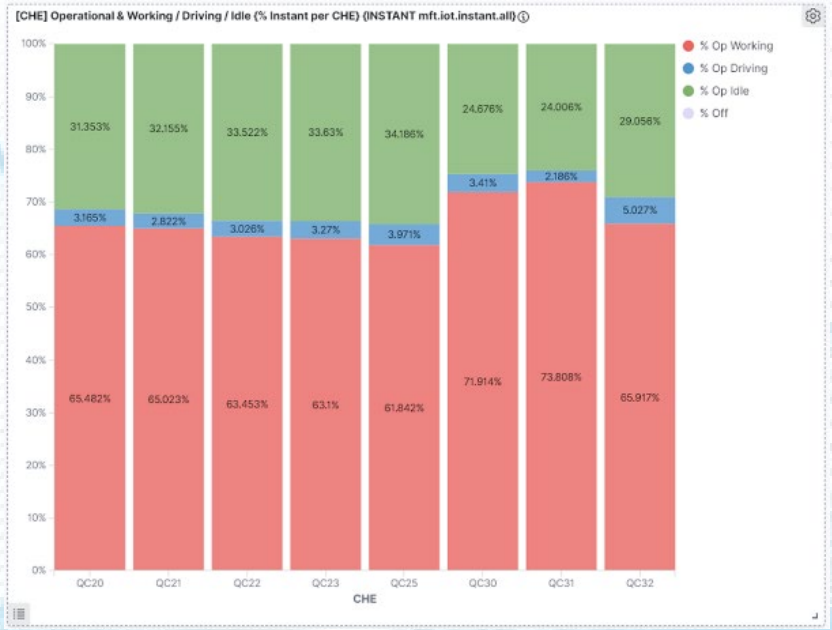
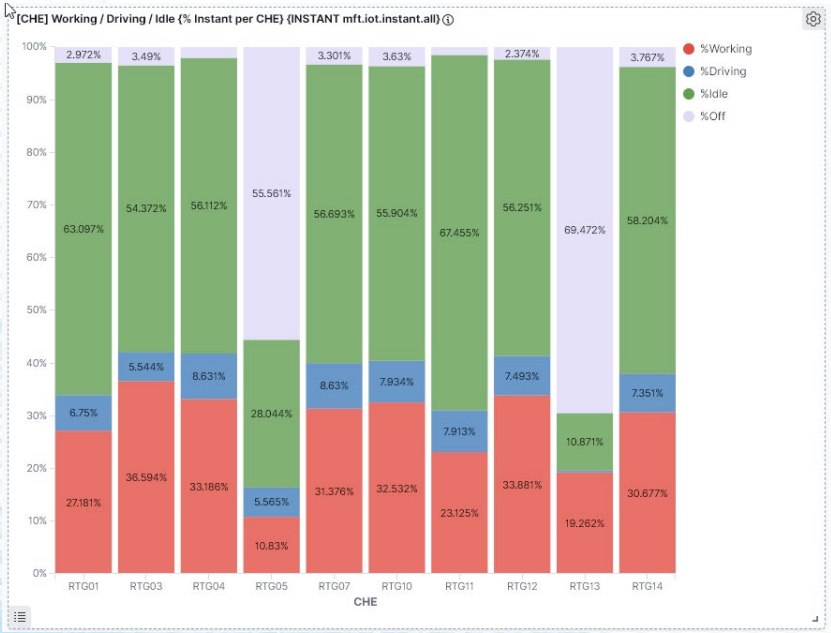
Hierarchical Data Model

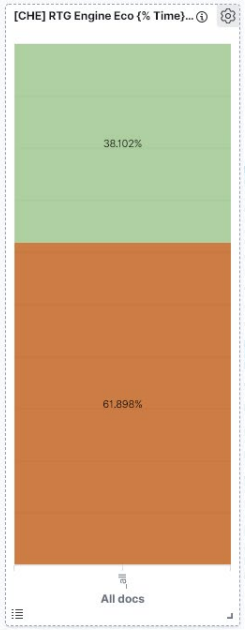


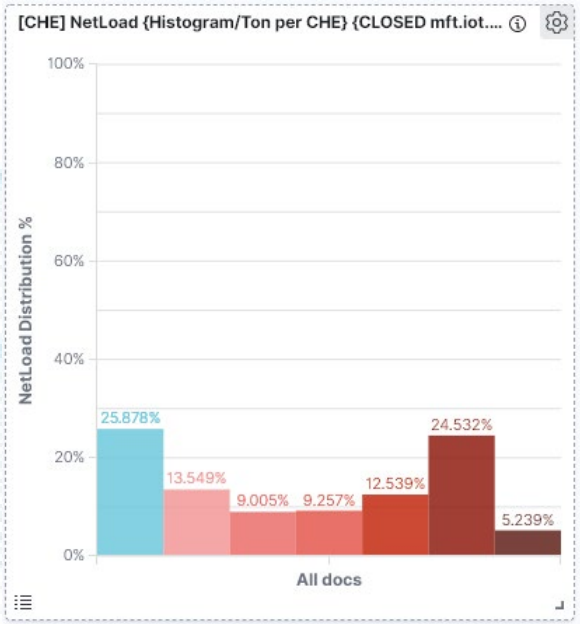
- Example: Idle time measurement

Off | **Idle** | **Gantry** | **Working**









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Example: “move”

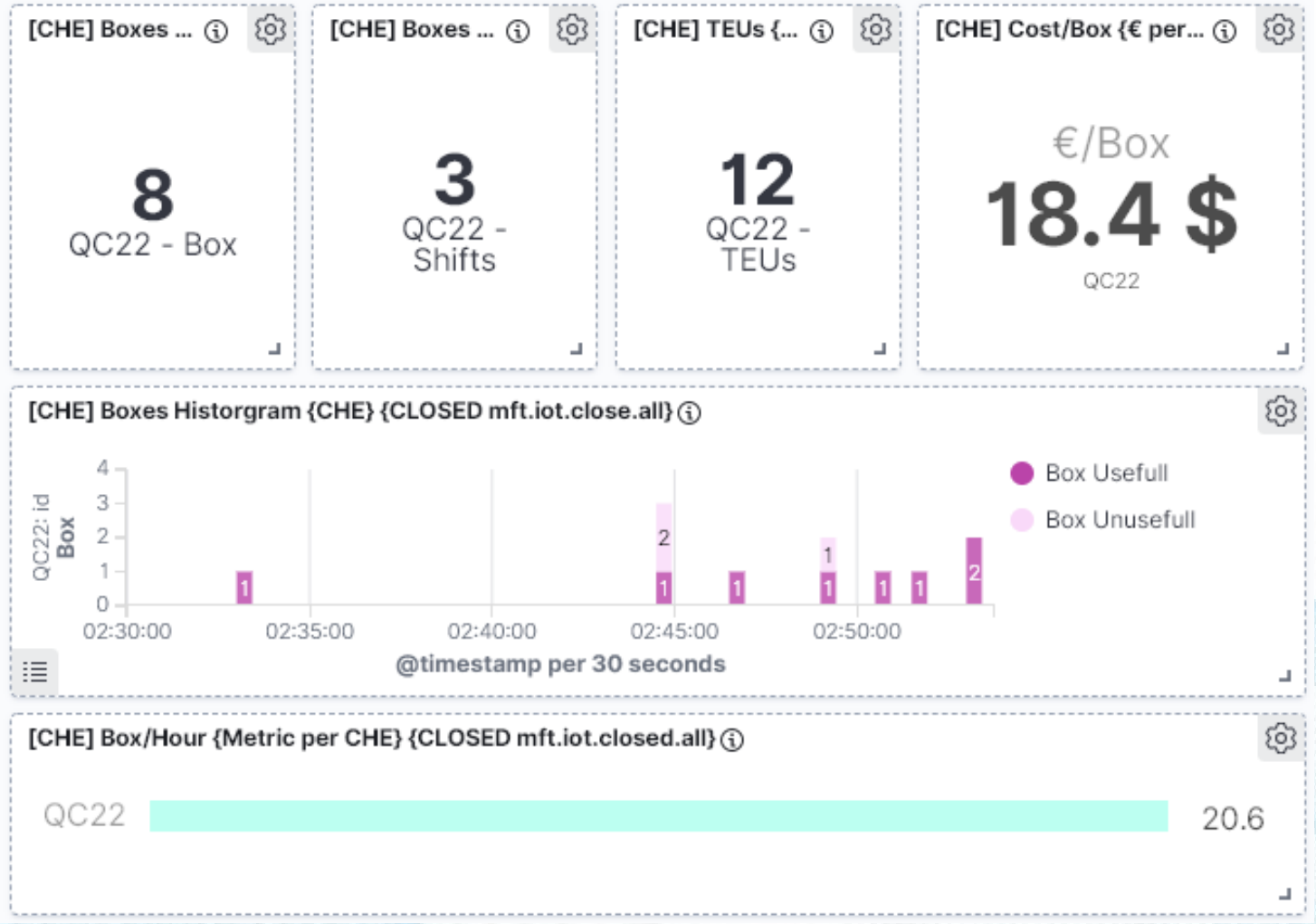
Don’t wait one hour to divide No. of boxes per hour anymore.

che.@.cycle.@.move.value

che.@.cycle.@.move.teu

che.@.cycle.@.move.box

che.@.cycle.@.move.cost



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iTerminals 4.0: Achieving the Port Container Terminal 4.0 Concept

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iTerminals 4.0

iTerminals 4.0 CEF Project will design, engineer, test and evaluate **Industry 4.0 solutions**, which will enable the **digital transformation towards the 'Container Terminal 4.0'.** This concept envisages a **hyper-connected facility** involving not only **smart equipment and systems**, but also **safety** and (**cyber**) **security** management by using integrated **big data analytics, artificial and predictive intelligence to reduce risk, increase sustainability and reduce energy consumption**. The 'Container Terminal 4.0' will perform cargo handling operations being data-driven, integrated and optimised to increase productivity, thus multiplying its automation capabilities.

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Energy Efficiency and Carbon Footprint: The Objective

Obtain the Carbon footprint and Energy Efficiency signatures of each container at the yard, from the logistics perspective.

Carbon footprint signature (logistic operative):

18 gCO2/kWh
11 kWh used
0.98 € in energy cost

Dynamic!

Energy efficiency label (logistic operative):

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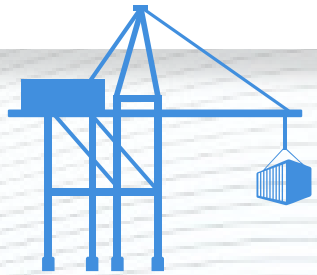
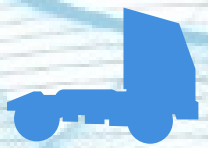
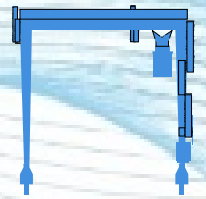
Measuring Energy

- Energy consumption from CHE:







che.cycle.energy.consumed

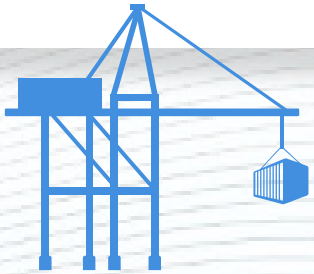
ENERGY

kWh (electricity)

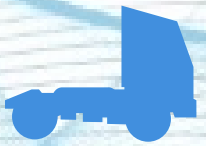
litres → **kWh eq.**

kg → **kWh eq.**

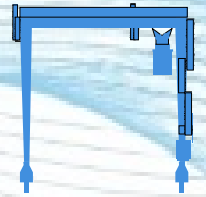
Energy Cost



Electricity tariff: TOU rates, cents€/kWh, €/kW and other charges



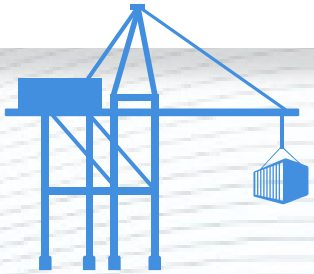
€ per litre, € per equivalent kWh

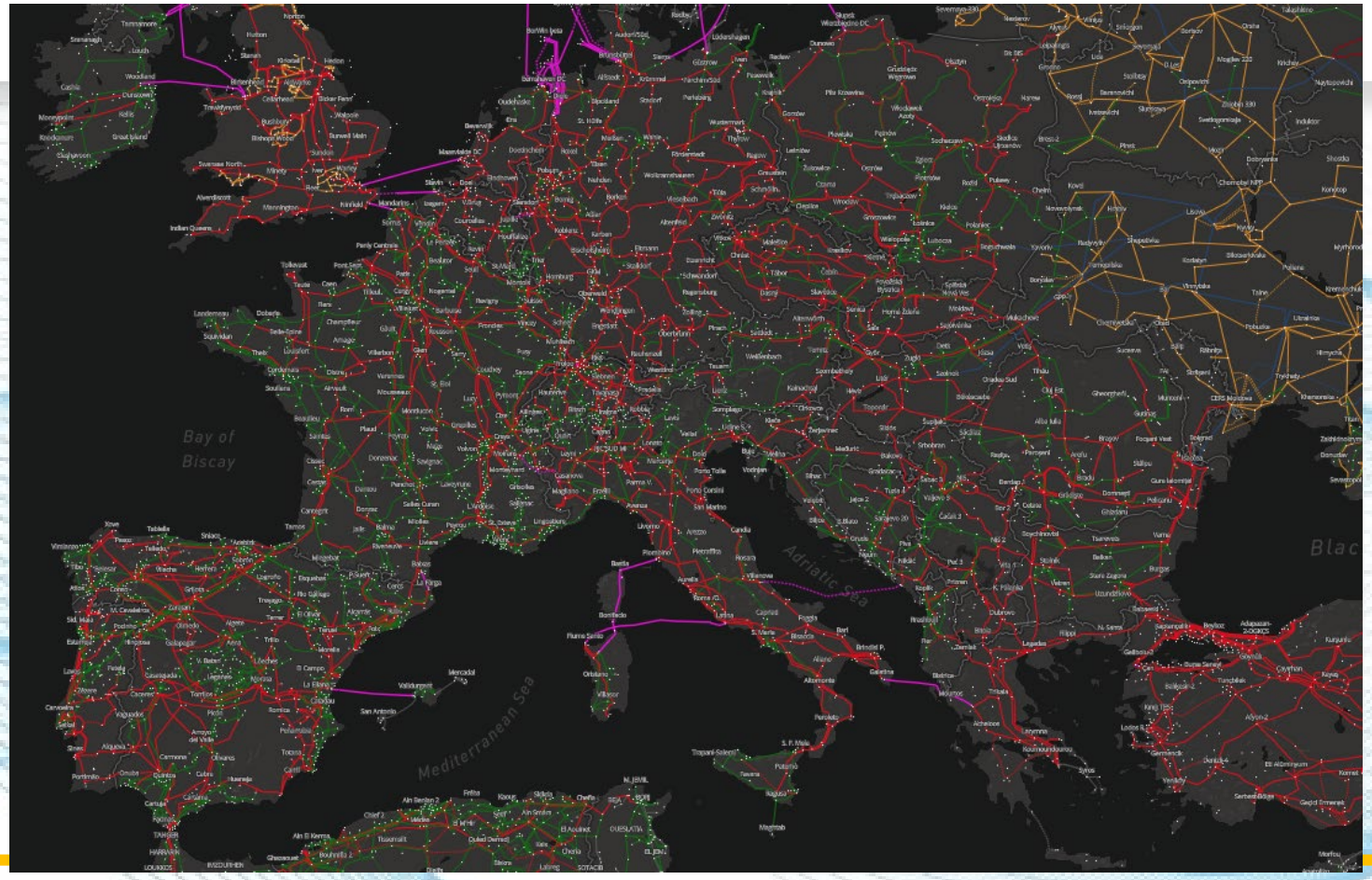


€ per litre, € per equivalent kWh

Calculating the carbon footprint

- Electricity: obtaining carbon footprint from the generation mix:

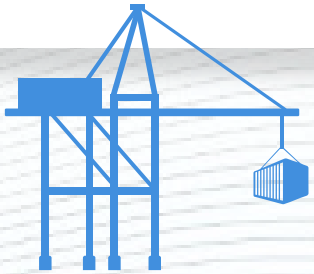




Source: ENTSO-E Grid Map

Calculating the carbon footprint (II)

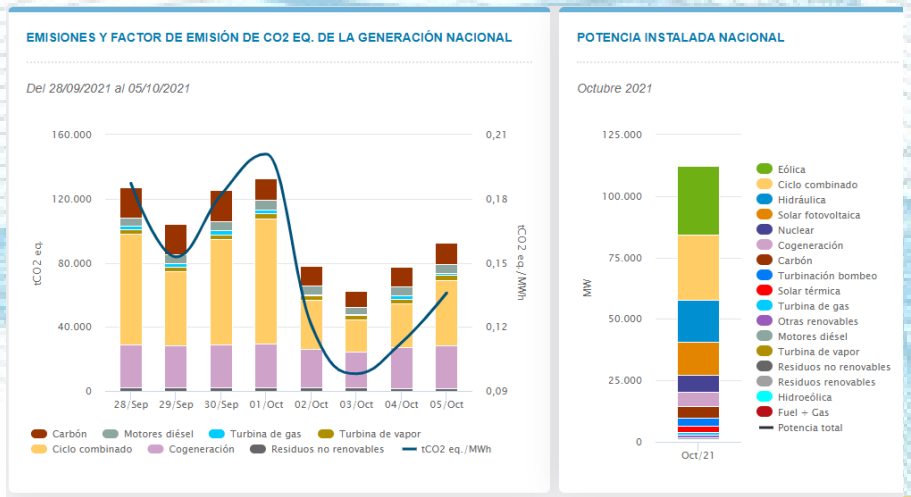
- Electricity: obtaining carbon footprint from the generation mix:



Information from national TSOs. For instance:

1. Spain (Red Eléctrica de España)
2. France (RTE)
3. Malta (eneMalta)

- Spain: tCO2 eq./MWh (Daily average)



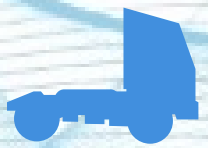
- France: gCO2 eq./kWh
(Values for each quarter hour)

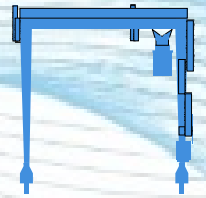
```
date_heure : 2021-10-06T07:00:00+00:00
ech_comm_angleterre : -718
hydraulique_step_turbinage : 819
hydraulique_lacs : 2535
eolien : 7166
hydraulique : 7852
solaire : 834
taux_co2 : 38
fioul_autres : 144
nucleaire : 41053
gaz_tac : -2
```

- Malta: computed on a yearly basis

Calculating the carbon footprint (III)

- Fuel consumption:





- Well-to-tank and Tank-to-Wheel emissions.
- Conversion to CO2 emissions based on energy consumed.
- Emission factor (CO2/kg) and Specific Consumption (g /kWh) values are needed.
- Bibliography available.

Defining KPIs

- Per cargo:

che.cycle.cargo

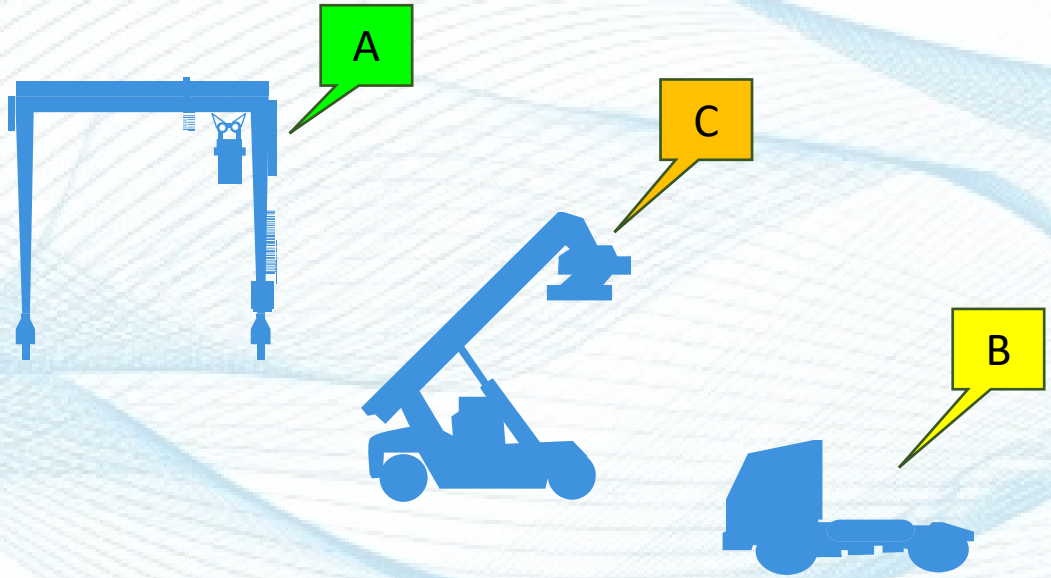
Carbon footprint signature (logistic operative):

18 gCO2/kWh
11 kWh used
0.98 € in energy cost

- Per move/cycle and machine:

che.cycle.

che.cycle.move



Visualization

Key Performance Indicators

Based on real values for each TEU, some indicators can be computed:

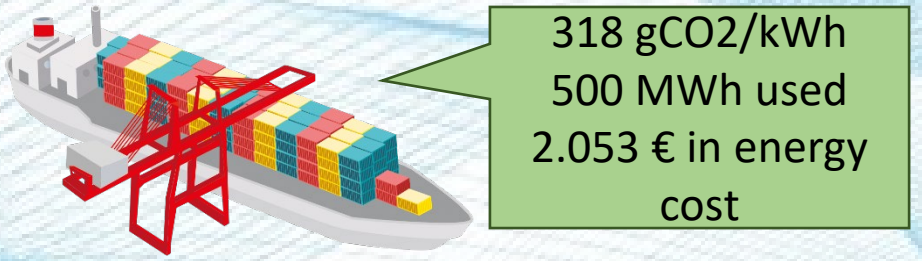
1- At **TERMINAL** level:

- KPI on global **carbon footprint per TEU,** computed as a rate (total carbon footprint / no. of TEU).
- KPI on global **carbon footprint per weighted Tonne.**

2 - At **SERVICE** level:

- Display **carbon footprint signature per service**. i.e., logistics carbon footprint and energy cost.

Carbon footprint signature (logistic operative):



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Visualization (II)

- Dynamic carbon footprint and energy cost per machine

Visualization options

- Ranking machines by time of use, energy consumed, energy cost and/or energy label.
- Displaying indicators' trends over time, per machine.

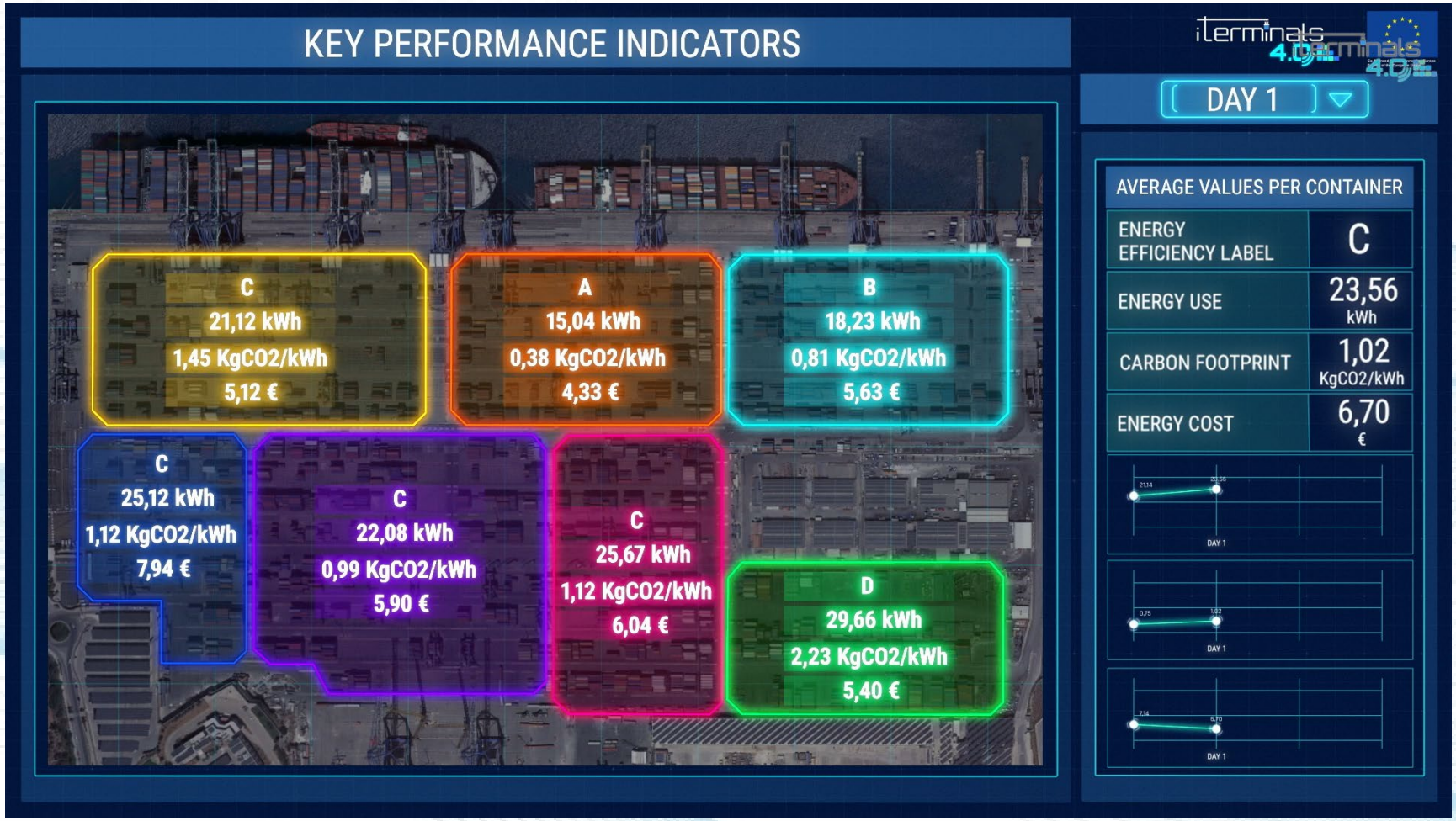
Machine	Hours	Energy used (kWh)	Energy cost (€)
STS_8	112	300	28
RS_3	200	285	122
…	…	…	…

Innovation / Progress beyond Business-as-Usual

- Real time visualization of energy use and cost per machine.
- Machinery energy efficiency labelling.
- It may help in preventive maintenance.
- It may help in optimizing the terminal management.

Visualization (III)

- Dynamic carbon footprint and energy cost per cargo



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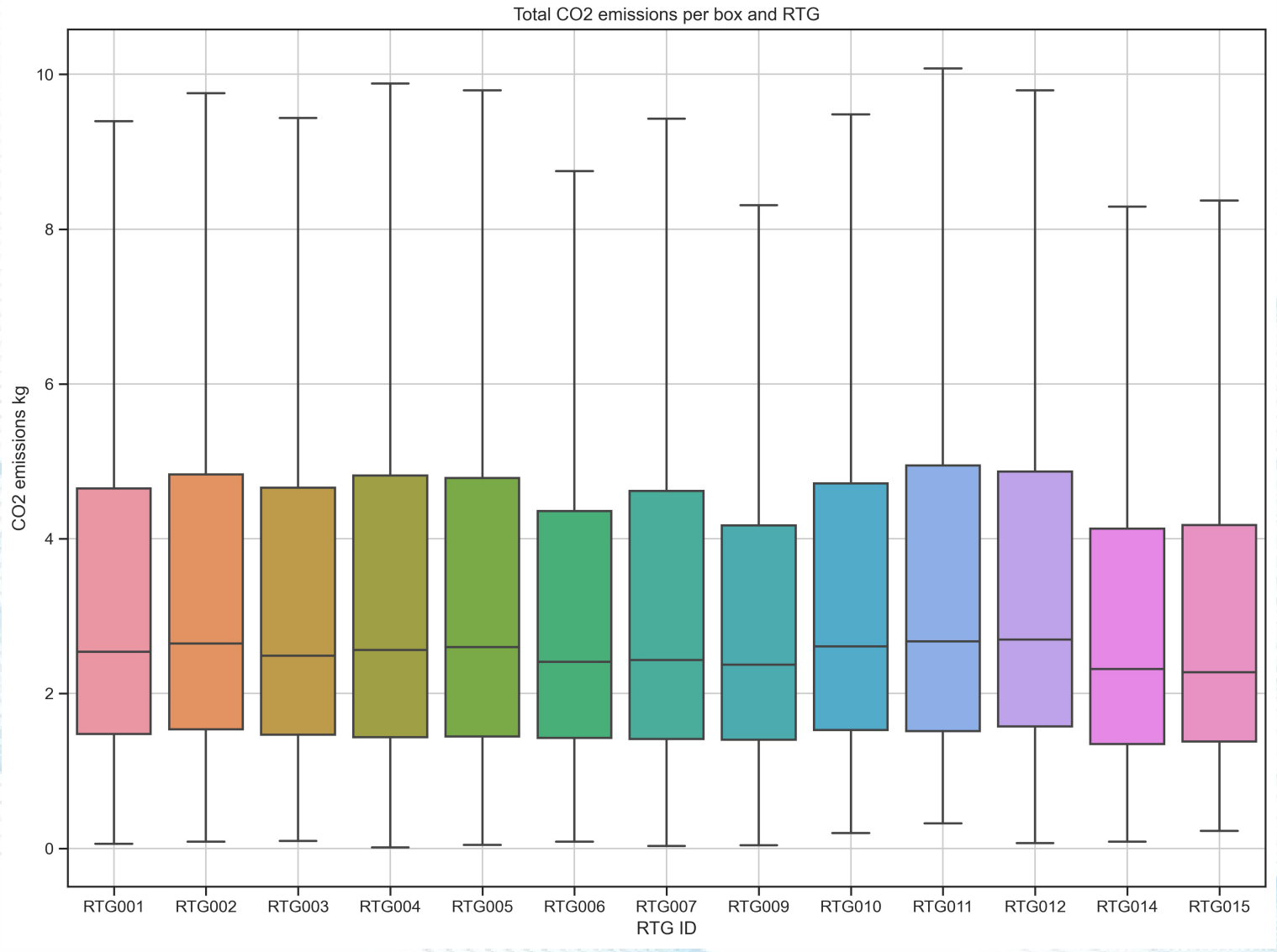
Implementation results: Malta Freeport



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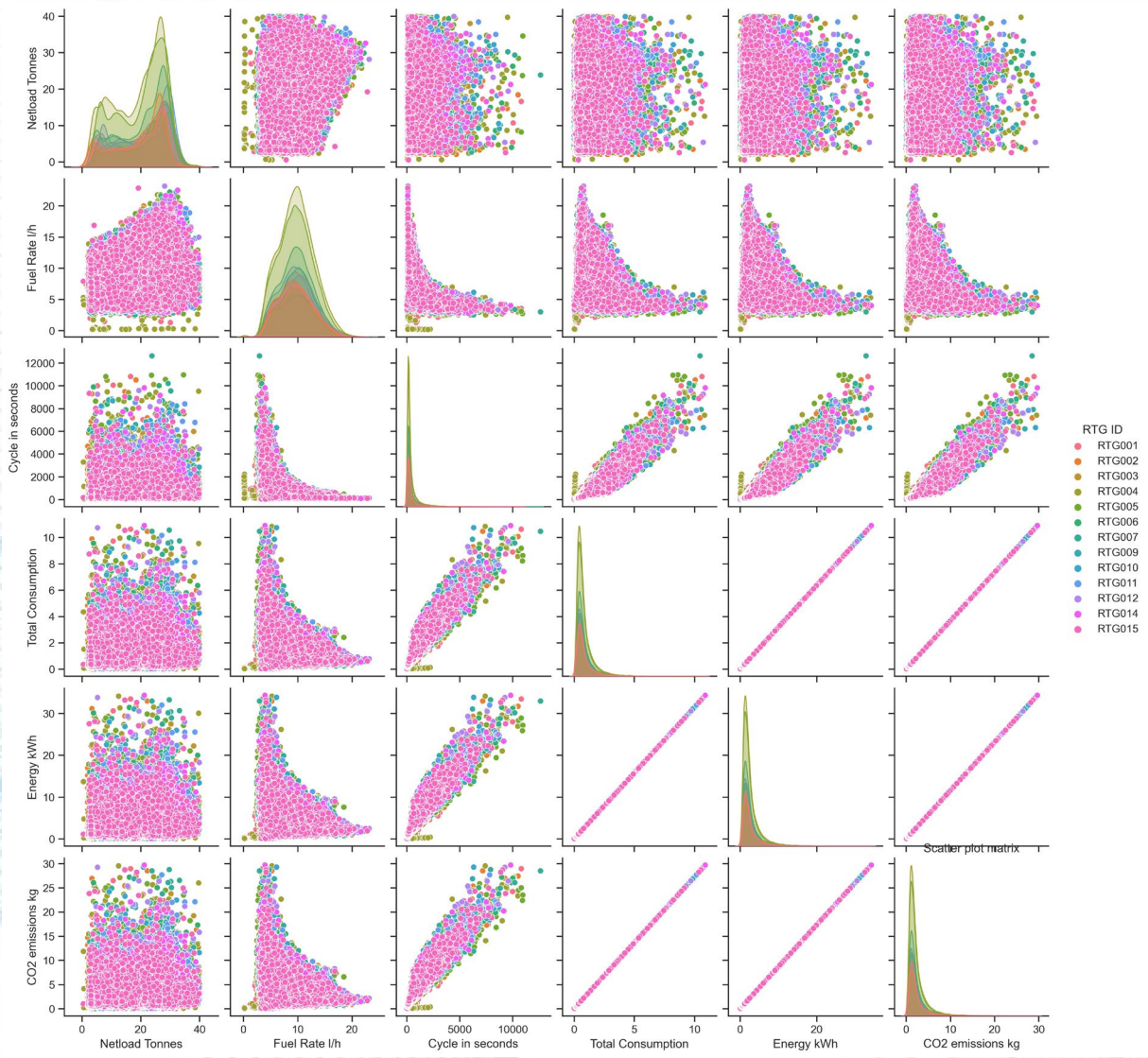
Implementation results: Malta Freeport



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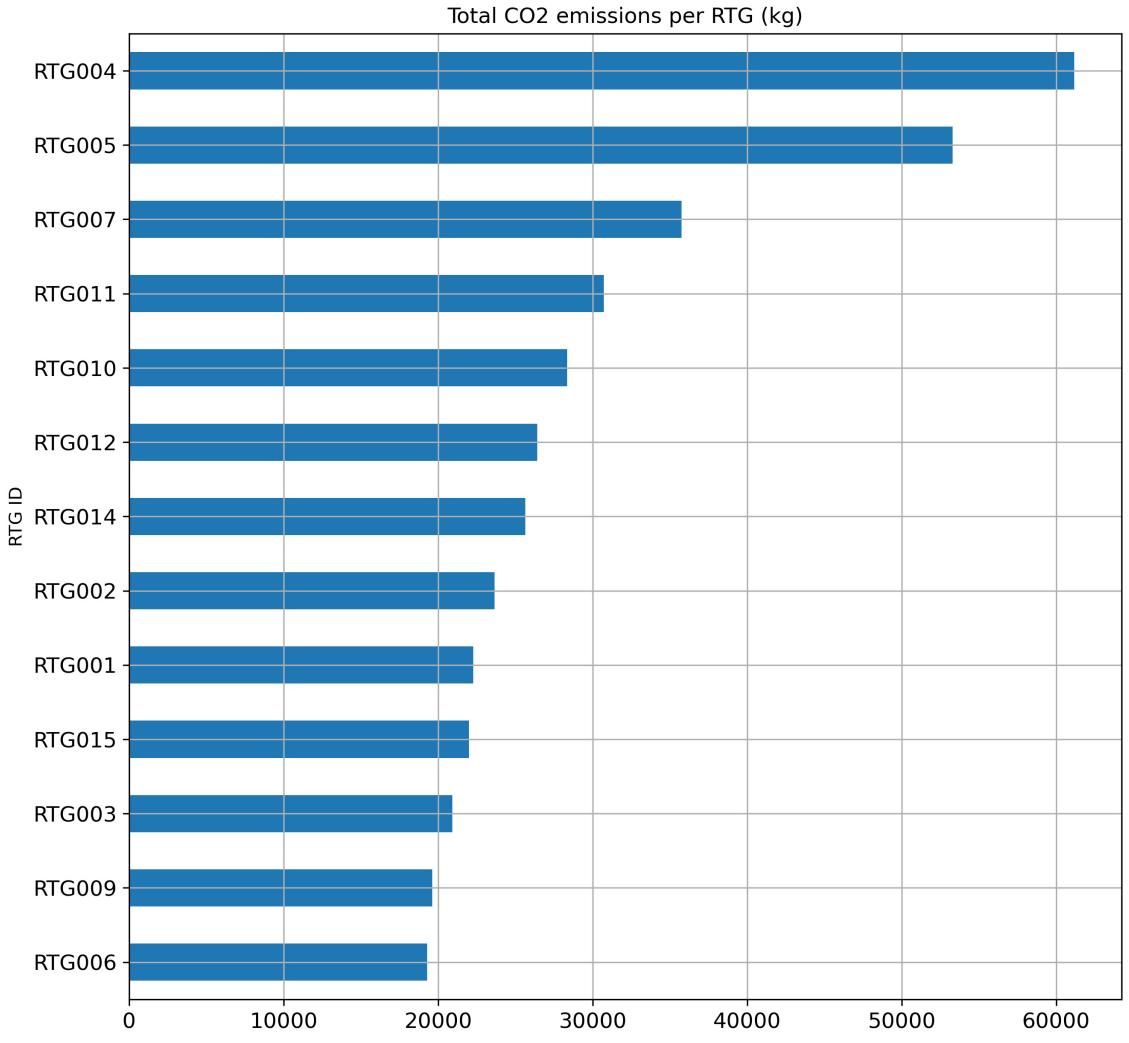
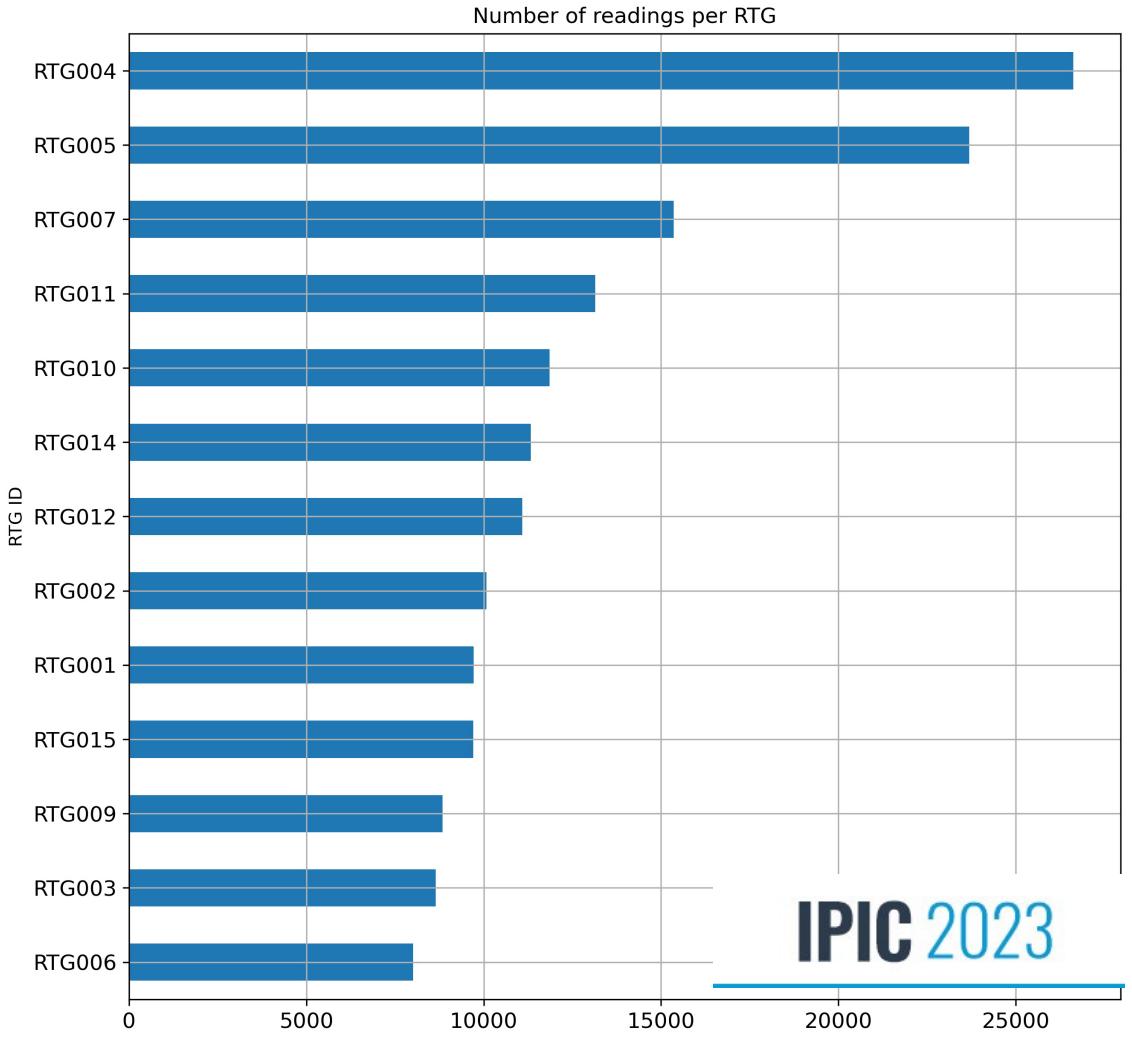
Implementation results: Malta Freeport





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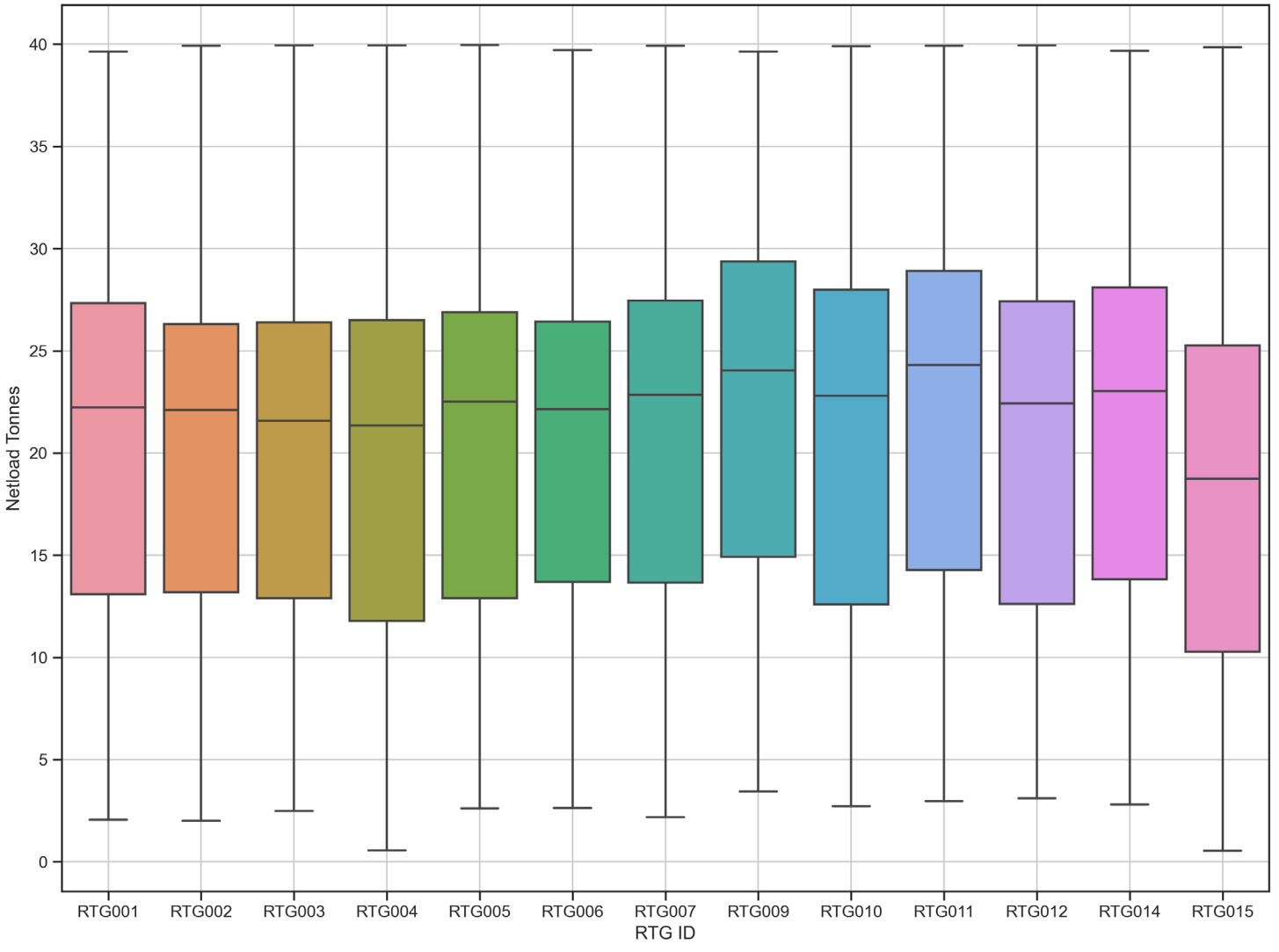
Implementation results: Malta Freeport



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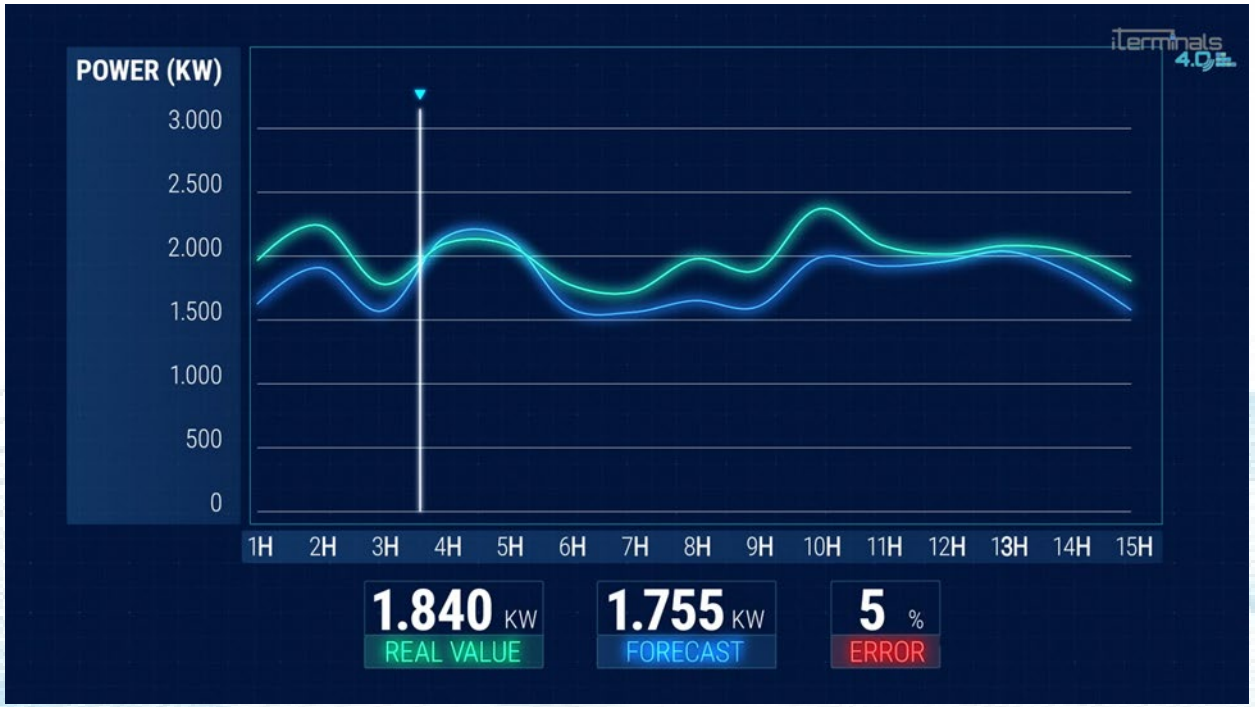
Conclusions

- Proof of concept.
- If you have the data, you can do it.
- Real time visualization of energy use and cost per cargo and per machine.
- Terminals can derive conclusions on the real energy costs and carbon footprint incurred to each TEU.
- Data can be obtained daily or even intra-daily. It is not necessary to wait for annual records or monthly bills.
- Insights are obtained with a detail level that go beyond a yearly or monthly average and estimate.
- Indicators can be associated to energy labels (A, B, C, D) at different levels: TEU, service, terminal.
- Trends and forecasts (energy use, energy efficiency).



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Thank you for your attention

Ignacio Benítez

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