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Energy & Data Transmission Systems

Port & Terminal Technology
Savanah, GA 2019

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OPEX Savings with Batteries on RTG‘s

- **Introduction to clean technologies on RTG‘s**
- **Battery solutions on RTG‘s**
  a) Hybrid-RTG
  b) Full E-RTG (Battery for block change + E-RTG system)
  c) Battery E-RTG (BE-RTG)
- **Outlook: Hydrogen and Fuel Cell‘s on RTG**

Introduction to Clean Technologies on RTG‘s

Different concepts to reduce fuel consumption and maintenance as well as emissions:

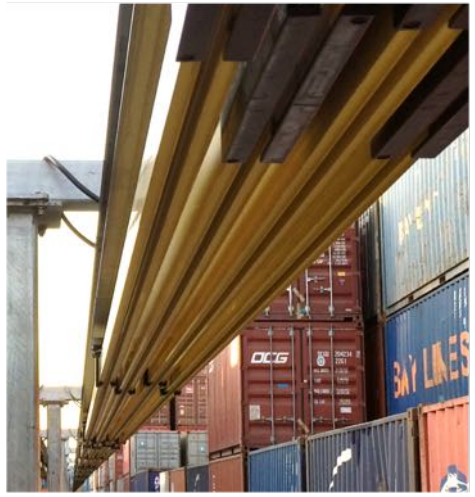
	Conventional RTG	Ecological RTG	Hybrid Battery RTG	Electrified and Battery RTG’s
Fuel	18 l/h 4.8 gal/h	13 l/h 3.4 gal/h	7 l/h 1.6 gal/h	about 25 kWh/h
CO2	541 kg/h	390 kg/h	211 kg/h	25 kg/h
Maintenance	50 h/year	50 h/year	20 h/year	2 h/year

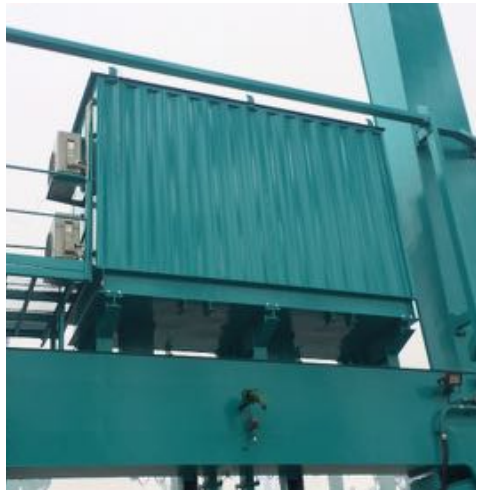
E-RTG solution = fuel and maintenance cost reduction and low or Zero Emission

E-RTG Solutions

Motorized Cable Reel Solutions	Conductor Rail Solutions	Hybrid Solution	Zero Emission Solutions
✓ Manual or automatic cable connection to grid power	✓ Manual or automatic connection to grid power	✓ Hybrid with a big battery pack and a small onboard genset	✓ Full E-RTG ✓ Battery E-RTG ✓ Fuel Cell Battery E-RTG

New possibilities with **Battery** solutions





OPEX Savings with Batteries on RTG‘s

- **Battery Solutions on RTG‘s**
  - a) **Hybrid-RTG**
  - b) Full E-RTG (Battery for block change + E-RTG system)
  - c) Battery E-RTG (BE-RTG)

Hybrid Solution H-RTG

Battery housing mounted under sill beam

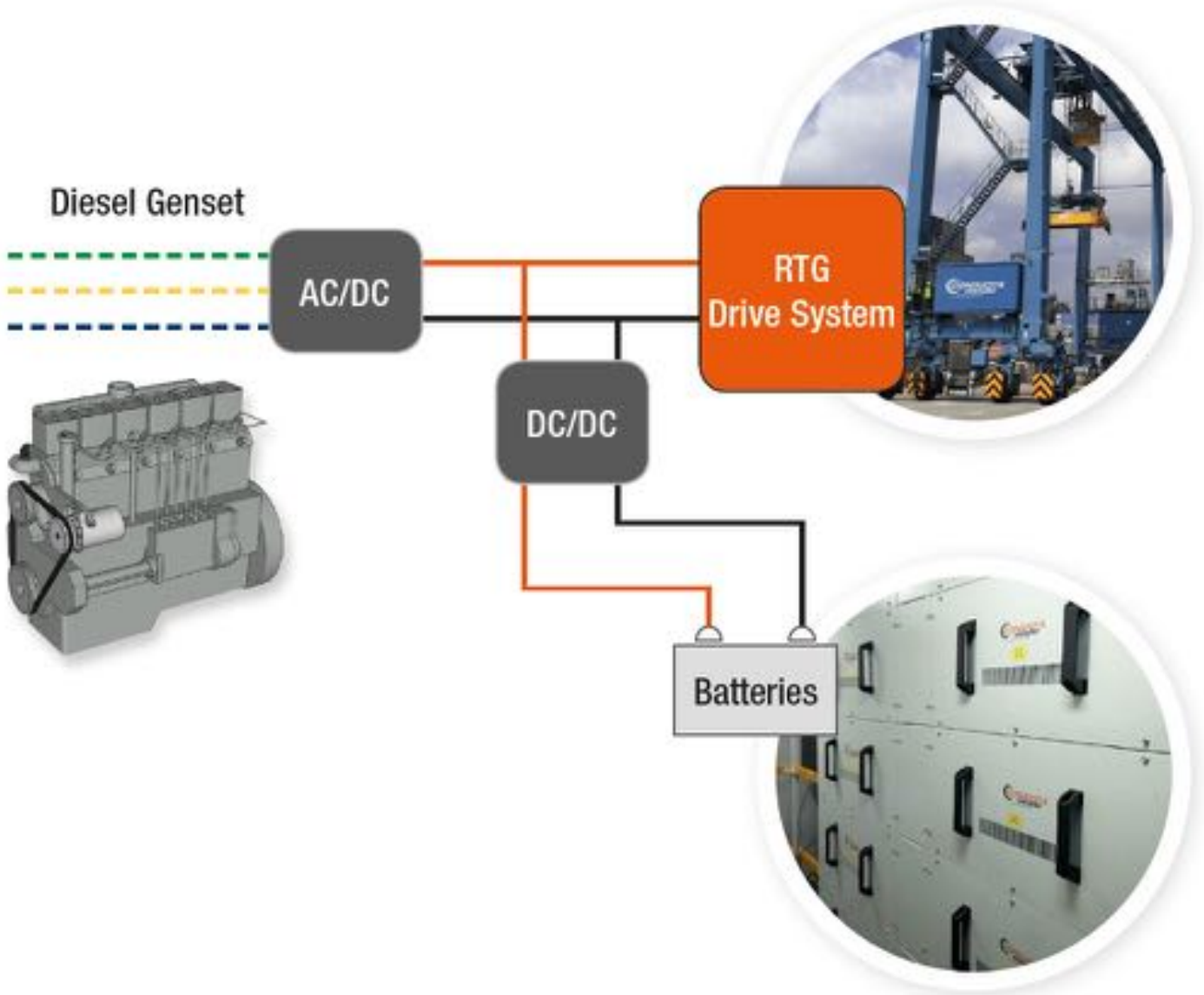
Battery modules inside the housing

Small diesel genset mounted under sill beam

HMI Touch Panel

- Equipped with a big battery pack powering **all** movements
- Small size Genset to charge the battery when needed (e.g. 100kW)
- Hybrid power pack connected to the DC/DC bus

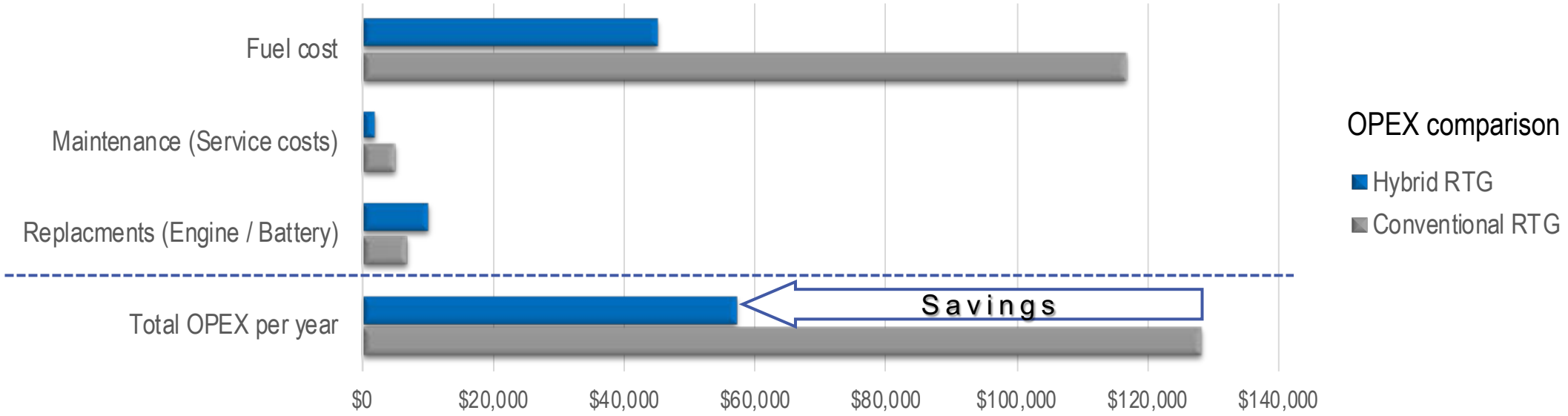
How Does Hybrid-RTG Work?



Hybrid Solution H-RTG

- Battery pack supports more than 30 container moves without recharging
- Regenerative energy during container lowering is fully utilized to charge the battery
- Up to 60% fuel saving compared with conventional genset
- Less Refueling operations
- Reduce maintenance cost
- Reduce considerably the environmental impact (CO2, NOx, SOx, particulates + noise)
- RTG maintains full operational flexibility (e.g. block changes), no changes in operation
- Independent from power grid
- No yard infrastructure is necessary

OPEX Savings with Hybrid-RTG



	Sample case	Conventional RTG	Hybrid RTG	Savings
		18l/h	7l/h	
Fuel saving per year	10 moves/h, 18 h/day, 300 days/year, 1.2 USD/l	116,640 USD/year	45,090 USD/year	**71,550 USD/year**
Maintenance service per year	100 USD/h	50h/year -> 5,000 USD/year	20h/year -> 2,000 USD/year	**3,000 USD/year**
Replacments (Engine / Battery)	15 years operation yearly average	6,670 USD/year	10,000 USD/year	**-3,330 USD/year**
			Yearly saving per RTG	**71,220 USD/year**

OPEX Savings with Batteries on RTG‘s

- **Battery solutions on RTG‘s**
  - a) Hybrid-RTG
  - b) **Full E-RTG (Battery for block change + E-RTG system)**
  - c) Battery E-RTG (BE-RTG)

FE-RTG Fully Electrified RTG
Block change powered by small battery pack

In Container Yard powered by grid power

Motorized Cable Reel

OR

Conductor Bar System

When RTG's are in stacking yard, they are powered by electricity supplied from power grid – either via conductor rails or cable reels

During block changes powered by FE-RTG battery pack

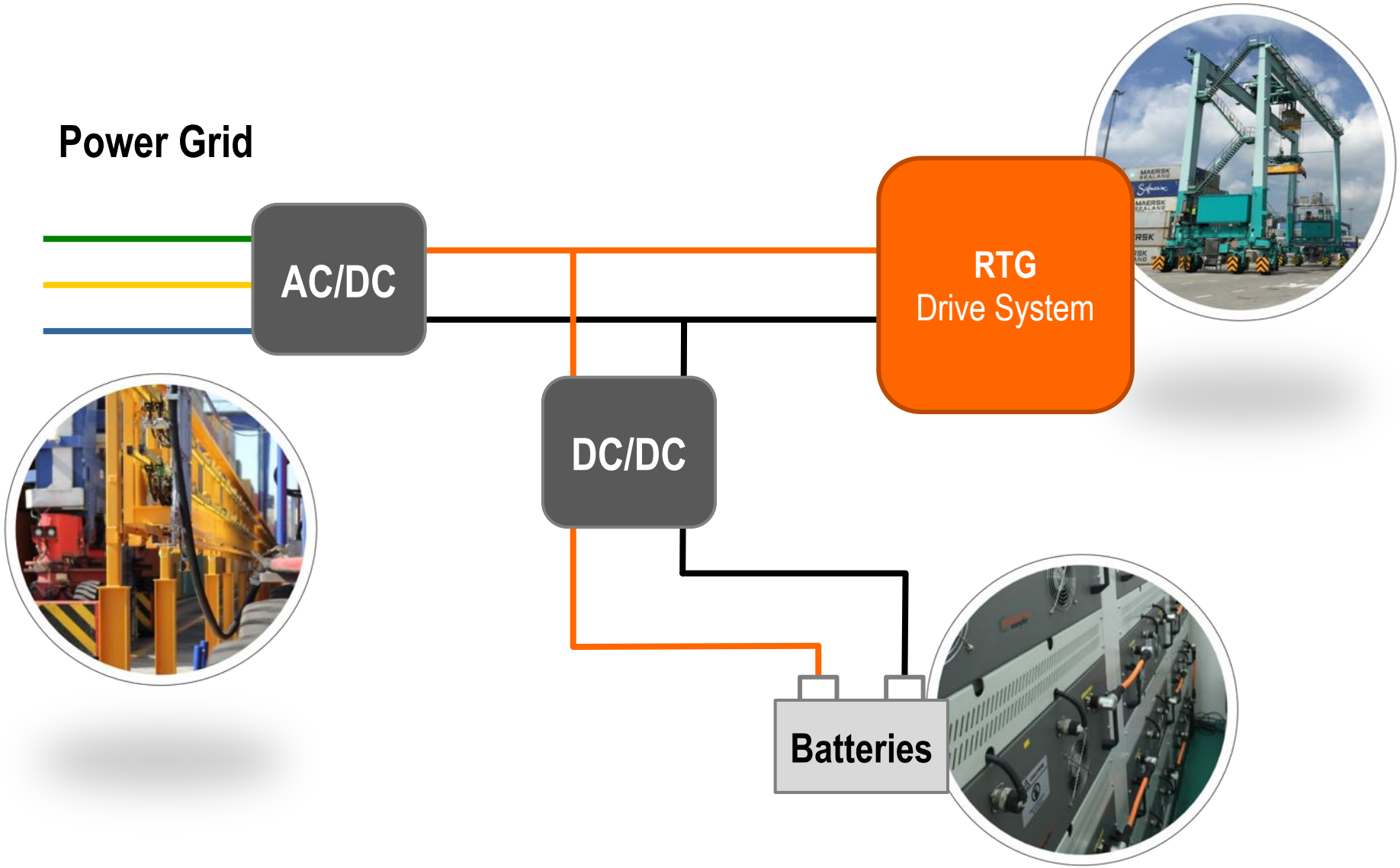
+ Battery

When RTG's are in block changing mode, they are powered by the energy stored in on-board battery pack

FE-RTG Fully Electrified RTG
Block change powered by small battery pack

- Li-Ion Battery packs replace the diesel genset
- Gantry travel for block changes up to 4900ft / 1500m powered by small battery system

How Does FE-RTG Work?

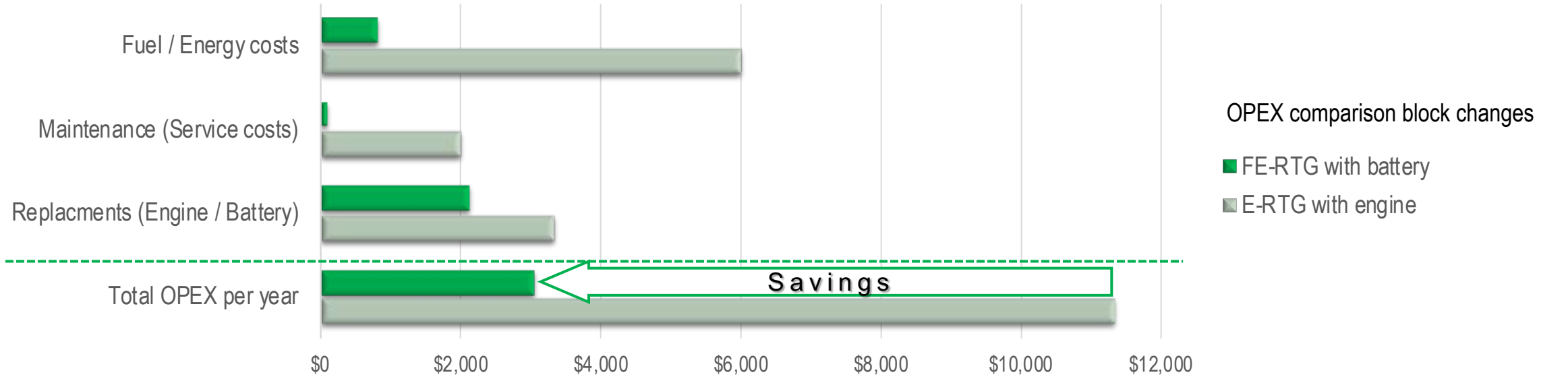


FE-RTG Fully Electrified RTG
Block change powered by small battery pack

Advantages of Full E-RTG:

- Reduce operating cost of diesel fuel during stack changes
- Reduce Maintenance cost for diesel engine
- Reduce RTG downtime during engine overhaul
- Store energy from container lowering and reuse during hoisting
- Reduce peak load energy demand from public grid / conductor rails
- Battery technology improving very fast
- Zero Emission (CO_2, NOx, SOx, particulates + noise)

OPEX Savings with FE-RTG Battery Pack for Block Changes



	Sample case	E-RTG with engine	Full E-RTG	Savings / Profit	Total
Block changes powered by		**Diesel engine**	**Battery**		**Total OPEX savings + additional profit through add. uptime** **8,275 USD/year**
Fuel / Energy saving per year	10 block changes/day, 300 days/year, 1.2 USD/l, 0.1 USD/kWh	6,000 USD/year	825 USD/year	**5,175 USD/year**	
Maintenance service per year (Engine / Battery)	100 USD/h	20h/year -> 2,000 USD/year	1h/year -> 100 USD/year	**1,900 USD/year**	
Replacments (Engine / Battery)	15 years operation yearly average	3,333 USD/year	2,133 USD/year	**1,200 USD/year**	
Increased operational uptime	RTG productivity: Profit 150 USD/h	0	84h/year -> 12,600 USD/year	**12,600 USD/year**	**12,600 USD/year**

Opex Savings with Batteries on RTG‘s

- **Battery Solutions on RTG‘s**
  - a) Hybrid-RTG
  - b) Full E-RTG (Battery for block change + E-RTG system)
  - c) **Battery RTG (BE-RTG)**

BE-RTG
Battery E-RTG with extra large battery pack

RTG is powered only by Extra-Large Battery Pack, which can be charged either manually or automatically.

+

Manual charging socket

Automatic charging station

How does BE-RTG work?

External Charging

AC/DC

DC/DC

RTG
Drive System

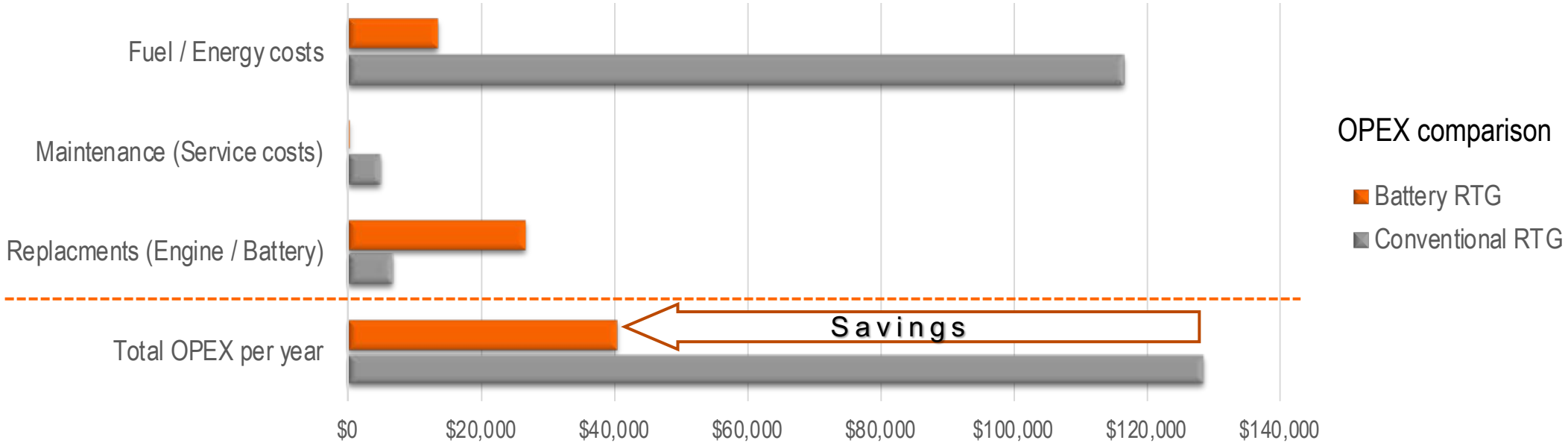
Batteries

BE-RTG
Battery E-RTG with extra large battery pack

Advantages of BE-RTG:

- Large battery pack supplying power for 1 or 2 work shifts
- Regenerative energy during container lowering is fully utilized to charge the battery
- Almost no maintenance
- A system developed from matured solutions and products
- Needed infrastructures are standard components (substations, charging stations)
- RTG maintains full operational flexibility (e.g. block changes), no changes in operation
- Zero Emission (CO2, NOx, SOx, particulates + noise)

OPEX Savings with Battery RTG (BE-RTG)



	Sample case	Conventional RTG	Battery E-RTG	Savings / Profit	Total
Fuel / Energy saving per year	10 moves/h, 18 h/day, 300 days/year, 1.2 USD/l, 0.1 USD/kWh	116,640 USD/year	13,500 USD/year	**103,140 USD/year**	**Total OPEX savings + additional profit through add. uptime**
Maintenance service per year (Engine / Battery)	100 USD/h	50h/year -> 5,000 USD/year	2h/year -> 200 USD/year	**4,800 USD/year**	
Replacments (Engine / Battery)	15 years operation yearly average	6,670 USD/year	26,666 USD/year	**-19,996 USD/year**	**87,944 USD/year**
Increased operational uptime	RTG productivity: Profit 150 USD/h	0	84h/year -> 12,600 USD/year	**12,600 USD/year**	**12,600 USD/year**

OPEX Savings with Batteries on RTG‘s

- Battery Solutions on RTG‘s
  a) Hybrid-RTG
  b) Full E-RTG (Battery for block change + E-RTG system)
  c) Battery E-RTG (BE-RTG)
- **Outlook: Hydrogen and Fuel Cell‘s on RTG**

=> Why Hydrogen and how can it be used on a RTG?

FBE-RTG Fuel Cell Battery RTG

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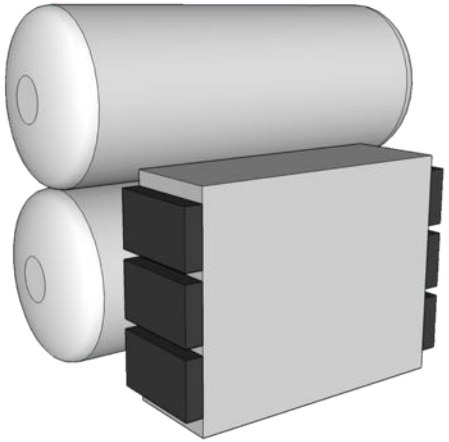
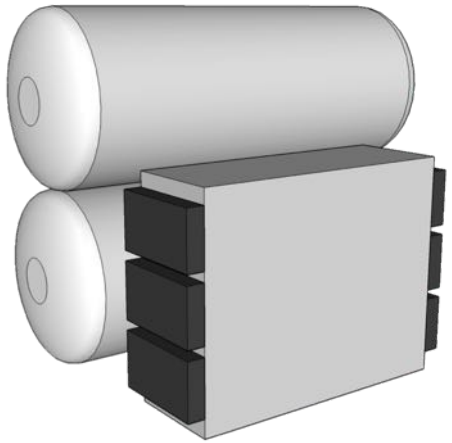


Fuel Cell and H2 tanks

RTG is powered only by Battery Pack, which is charged by on board Fuel Cell, when needed.

How Does FBE-RTG Work?

Fuel Cell +
Hydrogen tank



DC/DC

DC/DC

RTG
Drive System

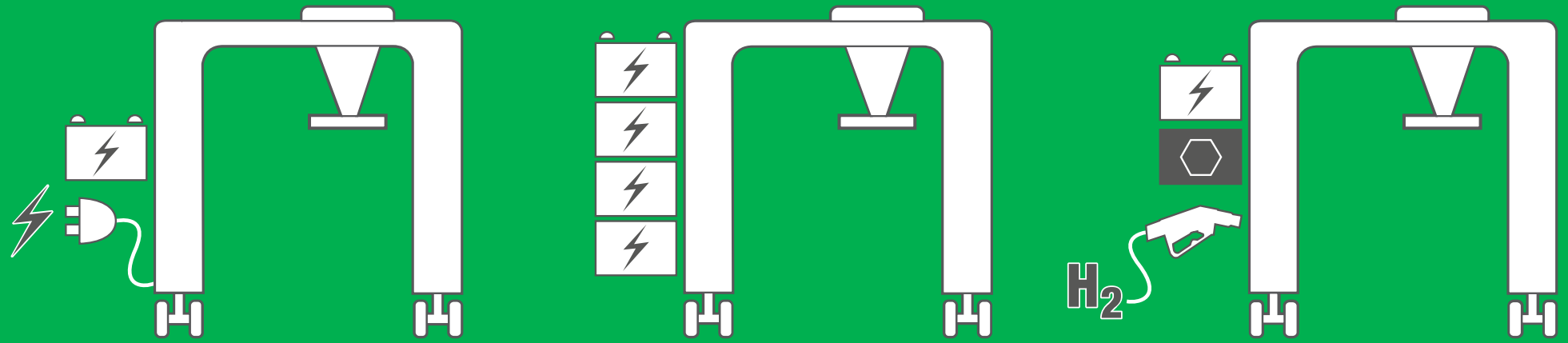
Batteries

FBE-RTG Fuel Cell Battery RTG

Advantages of FBE-RTG:

- Fast refueling capability with Hydrogen
- Maximized Fuel Cell life time vs. Fuel Cell only
- Battery pack supports more than 30 container moves without recharging (Hybrid concept)
- Regenerative energy during container lowering is fully utilized to charge the battery
- RTG maintains full operational flexibility (e.g. block changes), no changes in operation
- Independent from power grid
- Zero Emission (CO2, NOx, SOx, particulates + noise)

Overview: Zero Emission Solutions for RTG‘s



- **FE-RTG**
  Electrified RTG
  with grid power
  and small battery pack

- **BE-RTG**
  Electrified RTG
  with Extra-Large
  Battery Pack

- **FBE-RTG**
  Electrified RTG
  with fuel cell
  and battery pack

Thank you for your attention!

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