THE CAMFIL GROUP

Air Filtration Solutions
A vital contributor to the Energy Transition

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CLEAN AIR SOLUTIONS

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CAMFIL POWER SYSTEMS
MISSION

To provide turbomachinery reliable and intelligent air solutions for maximum predictability and minimum complexity.

POWER SYSTEMS

PROTECTING TURBOMACHINERY VIA HEAVY-DUTY FILTRATION AND NOISE CONTROL EQUIPMENT

Power Generation

Utility power groups
Independent power producers

Oil & Gas

Offshore installations
FPSOs
Refinery and pipeline compressor stations

Process

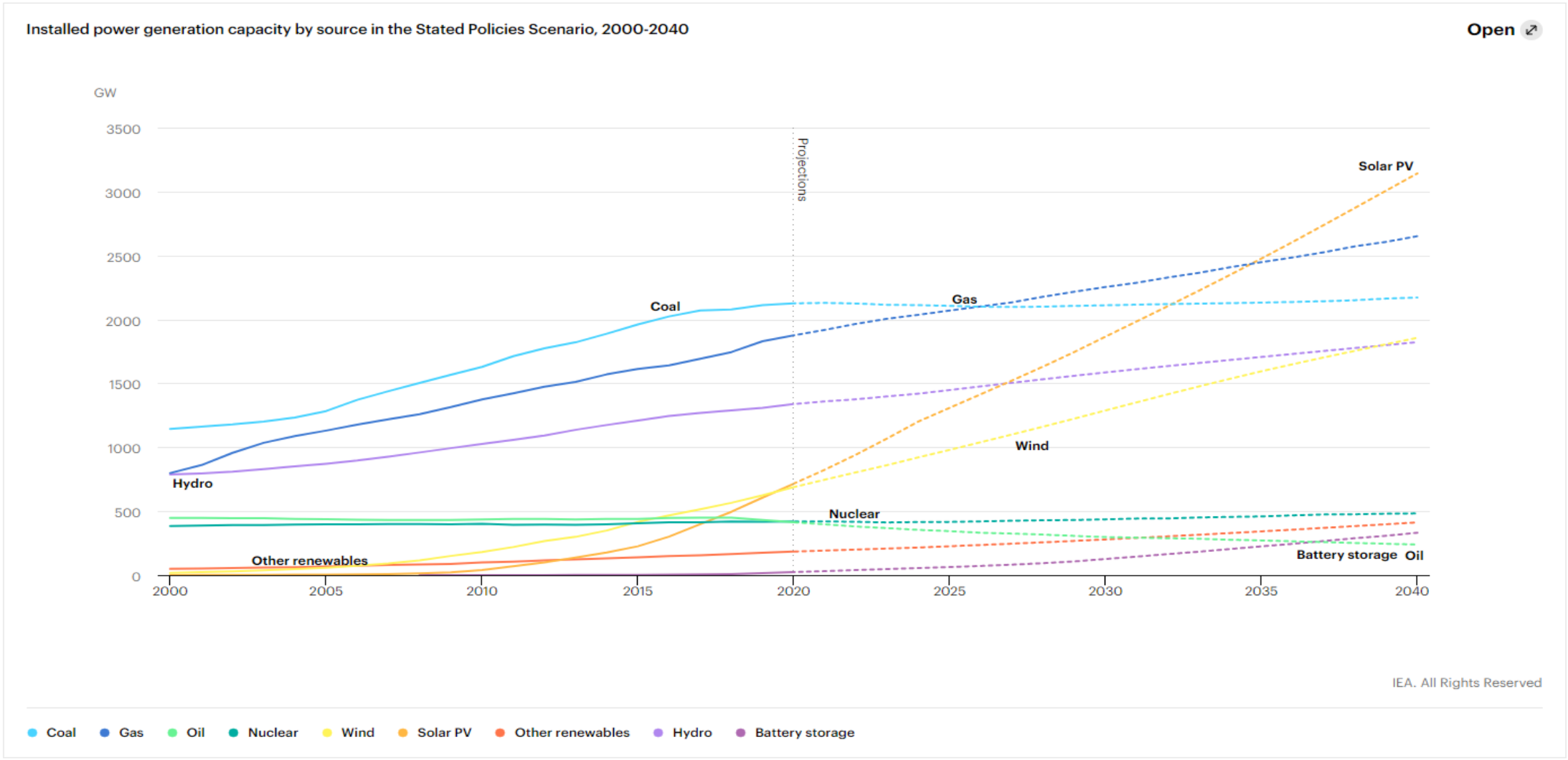
Gas production
Large industries
Public sector; transport, hospitals

AGENDA

- THE ENERGY TRANSITION
- How air inlet filters reduce CO_2 impact and fuel cost!
- What are the filter characteristics you need to look out for?
- Tools and Services: Boost To Reduce, The Value Rating and PowerEye
- Q&A

THE ENERGY TRANSITION

THE ENERGY TRANSITION



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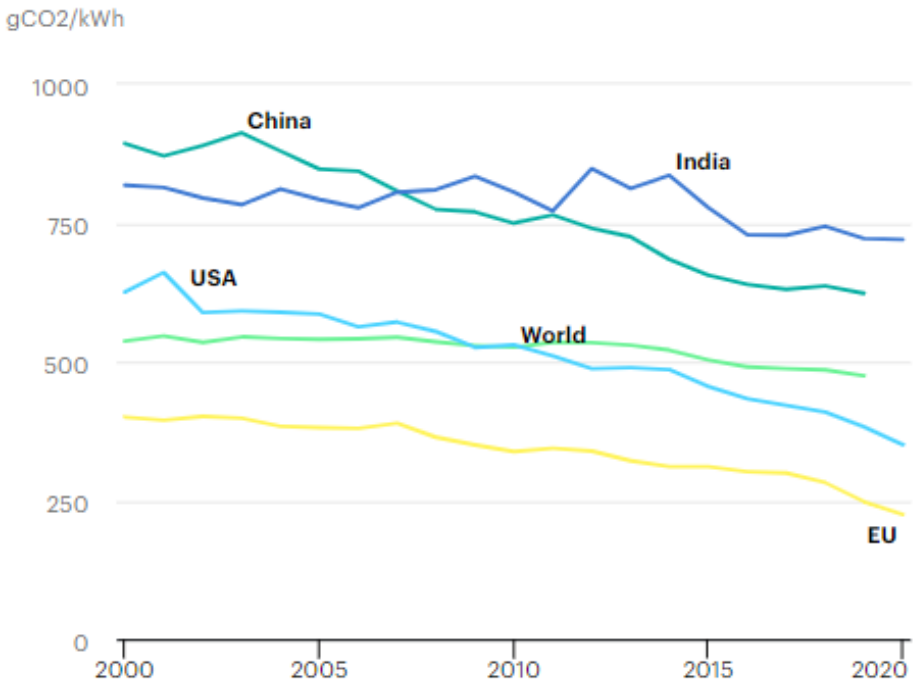
THE ENERGY TRANSITION

Carbon intensity of electricity generation in selected countries and regions, 2000-2020

Open



USA India World China EU

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DRIVERS FOR CUTTING YOUR CARBON FOOTPRINT

1 Greener corporate image

2 Increased regulations/ taxes

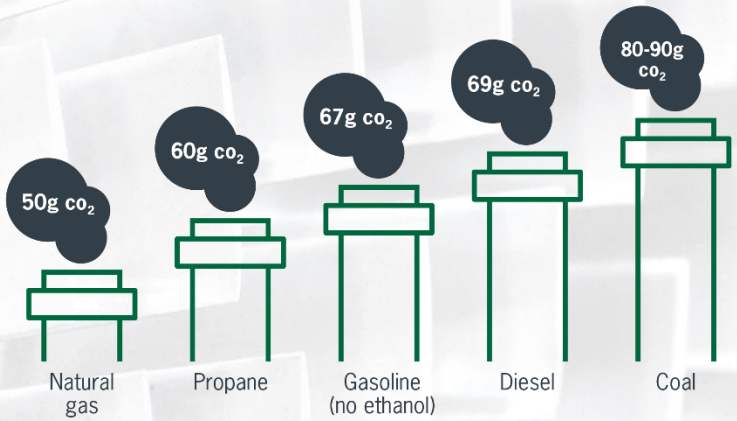
3 It’s the right thing to do

METHODS OF CUTTING CO_2

- Carbon capture
- Generate less carbon by using fuel with less carbon content – **THE HYDROGEN FUTURE**
  - **Race to enable Gas turbines to operate with 100% H_2**
- **Burn your current fuel more efficiently**
  - Use more efficient turbines
  - **Run your current and new turbines more efficiently**

Not all fuels are burned equally:
Different sources of energy emit different amounts of CO_2 per MJ of fuel burned.

Natural gas has one of the lowest carbon footprints of all fossil fuels; when compared to burning conventional coal fuel sources, natural gas releases nearly half the amount of carbon dioxide into the atmosphere.



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BETTER FILTRATION MEANS BETTER ENGINE PERFORMANCE

Less fouling & corrosion

+

Lower & stable dP

=

Less fuel burnt, **less CO_2** released per MWh

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BETTER FILTRATION MEANS
BETTER ENGINE PERFORMANCE

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HOW AIR INLET FILTERS REDUCE CO_2 IMPACT AND FUEL COST

IMPACT OF FUEL CONSUMPTION ON CO_2 OUTPUT

How much CO_2 is released when 1kg natural gas (~95% methane) is burned?

$$CH_4 + 2\ O_2 \rightarrow CO_2 + 2H_2O + \text{Heat}$$

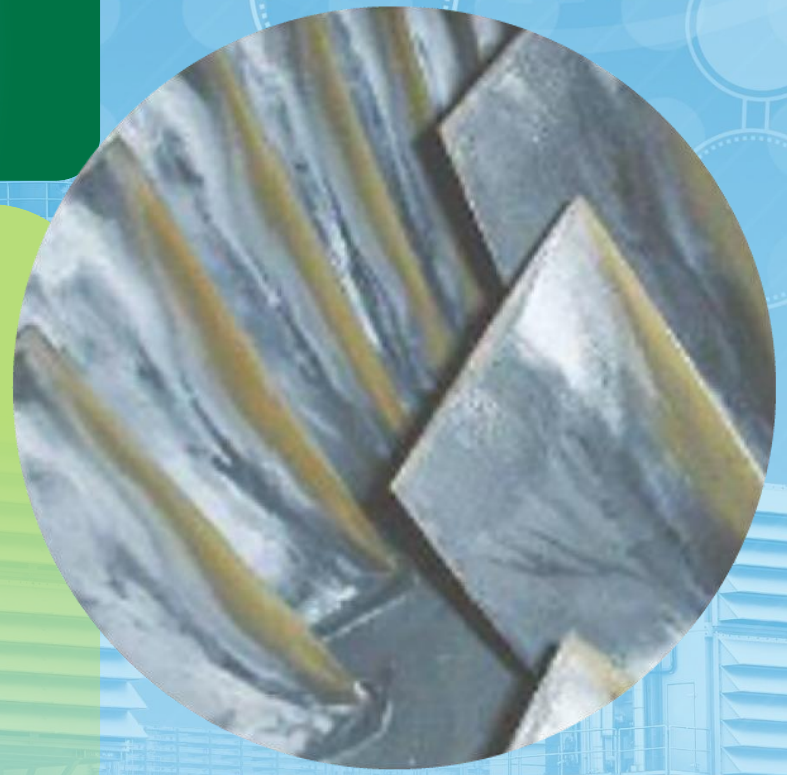
1 kg methane + 4 kg oxygen

→

2.75 kg carbon dioxide + 2.25 kg water

ROLE OF AIR FILTRATION ON YOUR GAS TURBINE

Particle buildup on gas turbines cause fouling



Fouled engines:

- Operate less efficiently
- Power output decreases
- **Heat rate increases**

IMPACT ON YOUR GAS TURBINE

1% higher heat rate (MJ/MWh)

=

1% more fuel burned per MWh

=

1% more CO_2 released per MWh

EFFECT OF FOULING ON YOUR GAS TURBINE PERFORMANCE

Final filter class (ISO29461-1)	Yearly change in power output (%)*	Yearly change in heat rate (%)**
T8	-4.8%	+2.4%
T11	-0.8%	+0.4%
Improvement:	**+4.0%**	**-2.0%**

Heat rate increase typically 40-60% of power output decrease **

* Schirmeister, Ulf, and Frederick Mohr. "Impact of Enhanced GT Air Filtration on Power Output and Compressor Efficiency Degradation." *Volume 3: Coal, Biomass and Alternative Fuels; Cycle Innovations; Electric Power; Industrial and Cogeneration; Organic Rankine Cycle Power Systems*, 2016, doi:10.1115/gt2016-56292.

** Meher-Homji, Cyrus B., et al. "The Fouling of Axial Flow Compressors: Causes, Effects, Susceptibility, and Sensitivity." *Volume 4: Cycle Innovations; Industrial and Cogeneration; Manufacturing Materials and Metallurgy; Marine*, Jan. 2009, doi:10.1115/gt2009-59239.

IMPACT OF FOULING ON YOUR CARBON FOOTPRINT AND FUEL BILL

T8 to T11 upgrade: +4% power capacity; -2% heat rate

Full load, per turbine:

- Power output ↑ 4%
- Heat rate ↓ 2%
- **Fuel consumed ↓ 2% per MWh**
- **CO_2 released ↓ 2% per MWh**

Part load, per turbine:

- Power output unchanged
- Heat rate ↓ 2%
- **Fuel consumed ↓ 2% per MWh**
- **CO_2 released ↓ 2% per MWh**

IMPACT OF FOULING REDUCTION CARBON FOOTPRINT

T8 to T11 upgrade: +4% power capacity; -2% heat rate

Assume Gas turbine operations

- 2000 TWh electricity produced
- ~774 million metric tonnes CO_2 output*

Potential savings (2%)

- ~15 million metric tonnes CO_2 per year
- ~7.5 kg less CO_2 per MWh produced
- ~2.7 kg less Fuel used per MWh produced

*https://www.wkcgroup.com/tools-room/gas-turbine-emissions-calculator-us-epa-ap-42/ assuming avg 47% efficiency (mix of OCGT, CCGT etc.)

WHAT ARE THE FILTER CHARACTERISTICS YOU NEED TO LOOK OUT FOR?

3 FILTER FEATURES TO CONSIDER

1. EPA grade efficiency

2. Hydrophobic filter construction

3. Low and stable pressure drop

ADDITIONAL IMPACT ON OPERATIONS

Increased availability

Less water washes
Fewer filter changes
Longer part life

Increased reliability

Less degradation
Lower risk of turbine trip
Meet output demands

Greater profitability

Higher output
Lower OPEX
Less taxes per MWh

TOOLS AND SERVICES

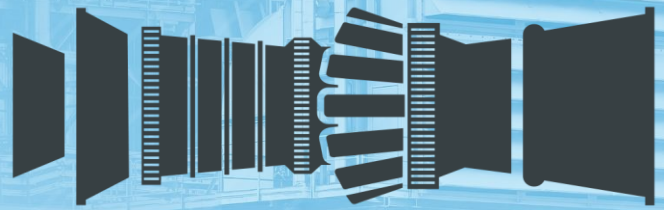
www.BoostToReduce.com

www.TheValueRating.com

www.Camfil.com/PowerEye

Boost to Reduce!

Upgrade GT Filtration to Slash CO_2 Emissions



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www.BoostToReduce.com

CALCULATE YOUR SAVINGS

LEARN MORE ABOUT HOW FILTRATION TECHNOLOGY IMPACTS CO_2 EMISSIONS

CO_2 EMISSIONS CALCULATOR

CO_2 TAX CALCULATOR

SUBMIT THE FORM TO GET ACCESS TO THE CALCULATORS

First name

First name

Last name

Last name

Company

Company

Email

Email

Country

I have read and accept the Privacy Policy terms and conditions (privacy policy information).

I'm not a robot

reCAPTCHA
Privacy - Terms

SUBMIT

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CO_2 EMISSIONS CALCULATOR

CALCULATE YOUR CO_2 EMISSIONS AND POTENTIAL SAVINGS

PLEASE FILL IN THE REQUESTED DATA ACCORDING TO YOUR CURRENT OPERATIONS

Average power demand in MW per hour

2000

Operating hours / year

8000

Heat rate in kJ/kWh

6500

Current final filter class

F8 (MERV14)

SUBMIT FORM

◀◀ Make another calculation

RESULT

With your current **F8** solution, you emit **88 413** tonnes of CO_2 per year as a result of fouling. With an upgraded solution, you would be able to reduce emissions by **78 473** tonnes while producing the same **16 000 000** MWh per year.

CONTACT US TO KNOW MORE

CONTACT US

** This calculator indicates how filtration has an impact on CO_2 emissions based on a fixed amount of MWh produced per year.*
** This comparison is based on upgrading your current filter class to a high grade EPA filter solution. Depending on a filter's average pressure drop and hydrophobicity, you can further reduce your CO_2 emissions. Contact your nearest local representative for a more accurate calculation.*

Disclaimer: Data inputs and results are not stored.

CO_2 TAX CALCULATOR

CALCULATE YOUR POTENTIAL TAX SAVINGS

PLEASE FILL IN THE REQUESTED DATA ACCORDING TO YOUR CURRENT OPERATIONS

Average power demand in MW per hour

2000

Operating hours / year

8000

Heat rate in kJ/kWh

6500

Current final filter class

F8 (MERV14)

Relevant production unit

MWh

Price per MWh (USD $)

35

CO_2 tax rate (USD $)

20

Net margin (%)

8

SUBMIT FORM

◀◀ Make another calculation

RESULT

With an upgraded filter solution, you would be able to reduce your CO_2 tax bottom line by **$1 569 464** USD per year.
To generate the same bottom line results, you would need to produce an additional **560 523** MWh in that fiscal year.

CONTACT US TO KNOW MORE

CONTACT US

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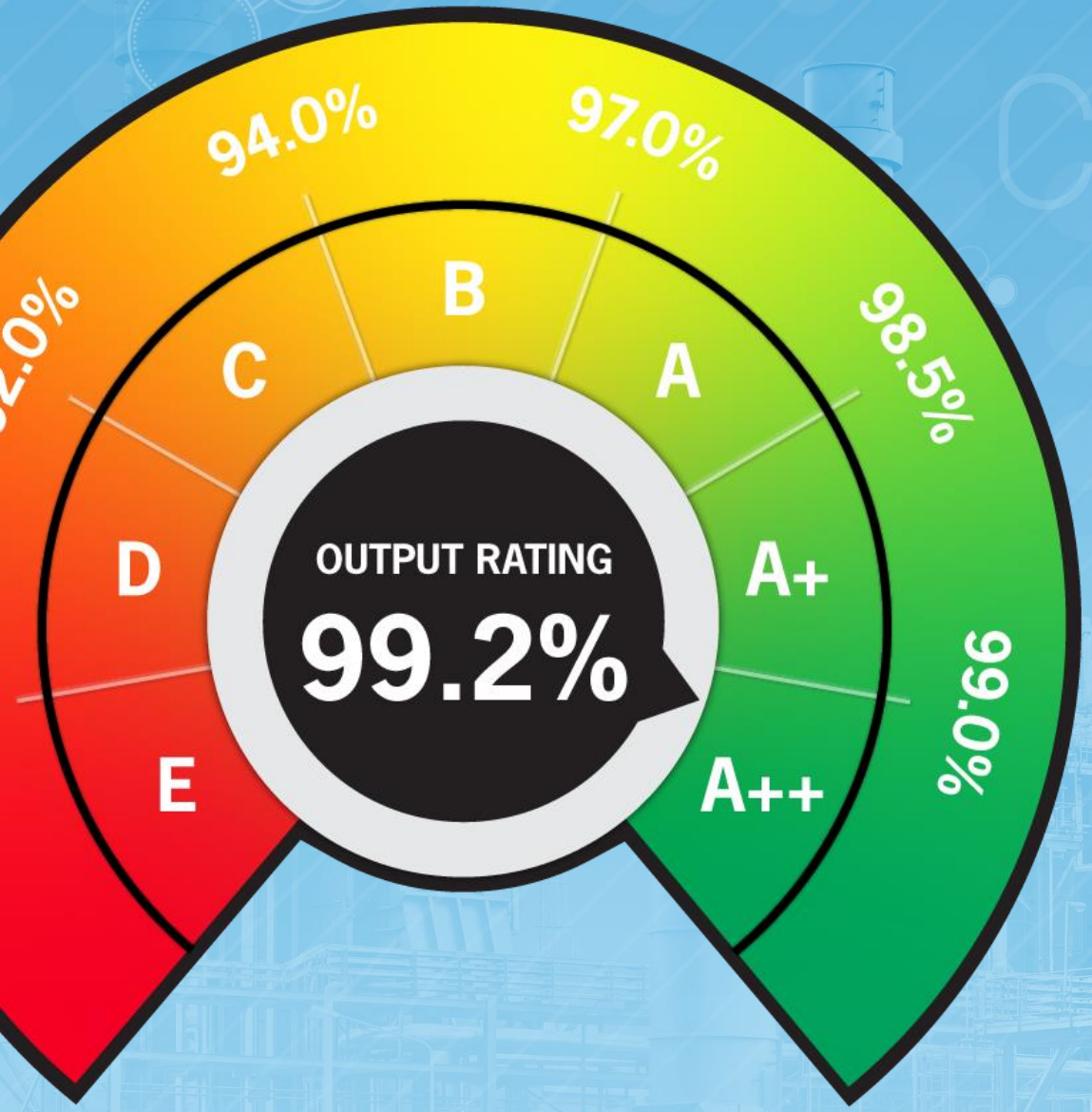

THE VALUE RATING

The easiest way to select the best filters for your gas turbines

A new way to compare air filter performance

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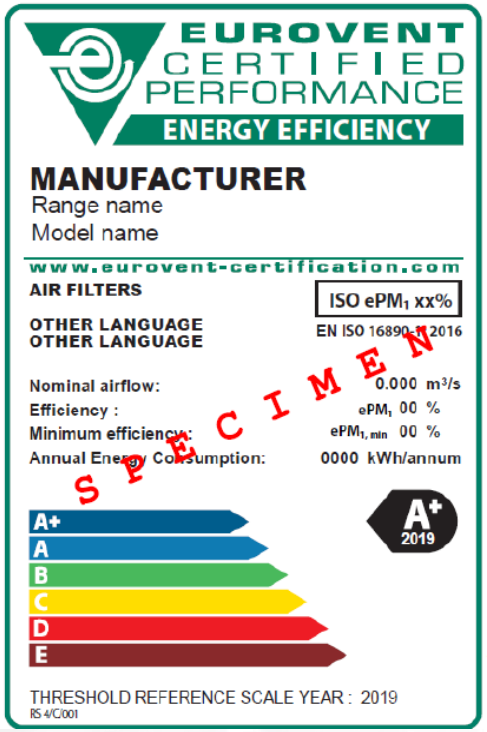
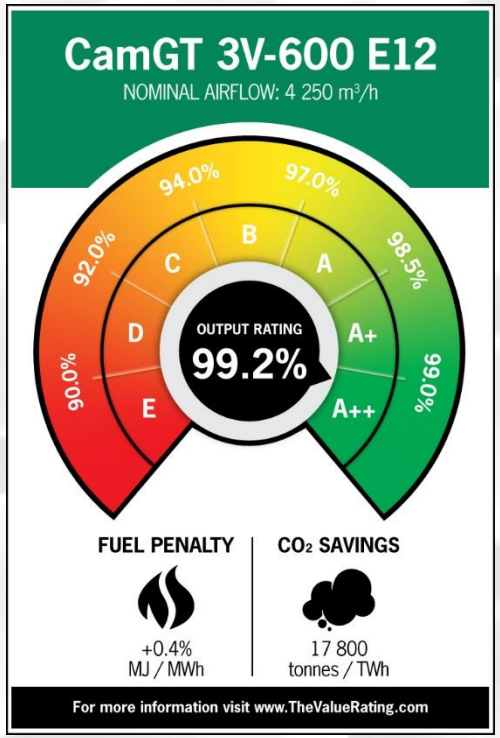
THE VALUE RATING CONCEPT
EUROVENT / ENERGY RATINGS





EUROVENT RATING:

- Specific for electric motors
  - Pressure drop only – Energy consumption

THE VALUE RATING:

- Specific to stationary gas powered turbines
  - Pressure drop AND efficiency – Energy consumption

The Value Rating

When determining the true performance of your filters, you need to **look deeper than just the efficiency rating**

More **comprehensive rating**: Combine efficiency with both dP and DHC from your ISO 29461-1 report to **translate filter data to engine performance**

The Value Rating has been **updated to work in harmony** with ISO 29461-1

THE VALUE RATING
3 KEY OUTPUTS

POWER OUTPUT

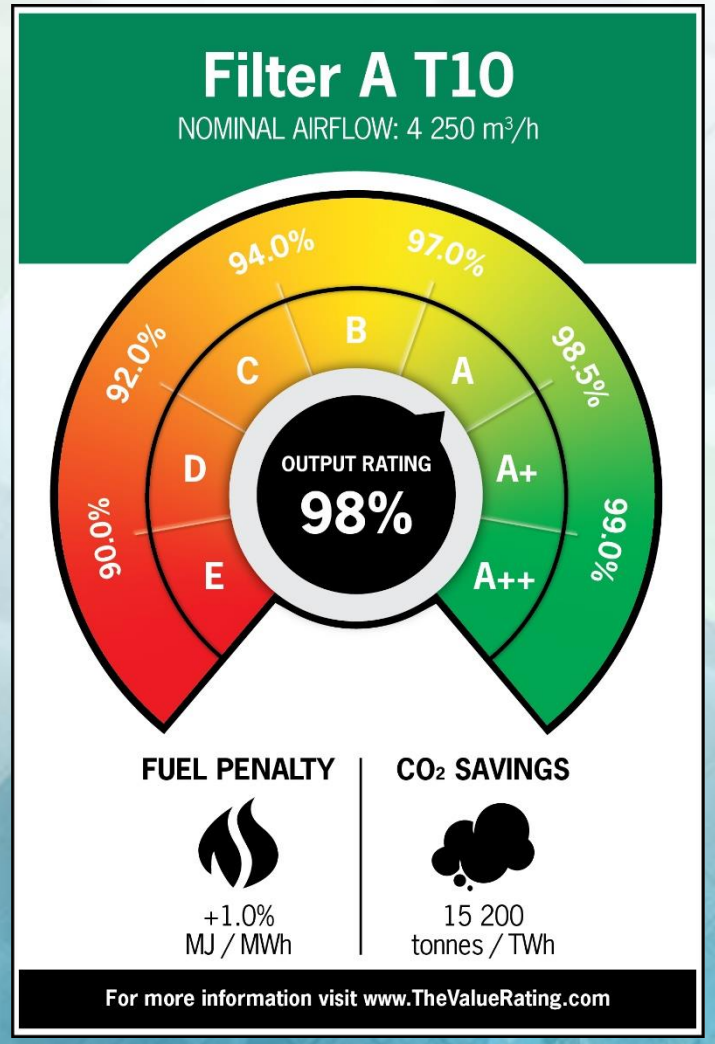
FUEL EFFICIENCY

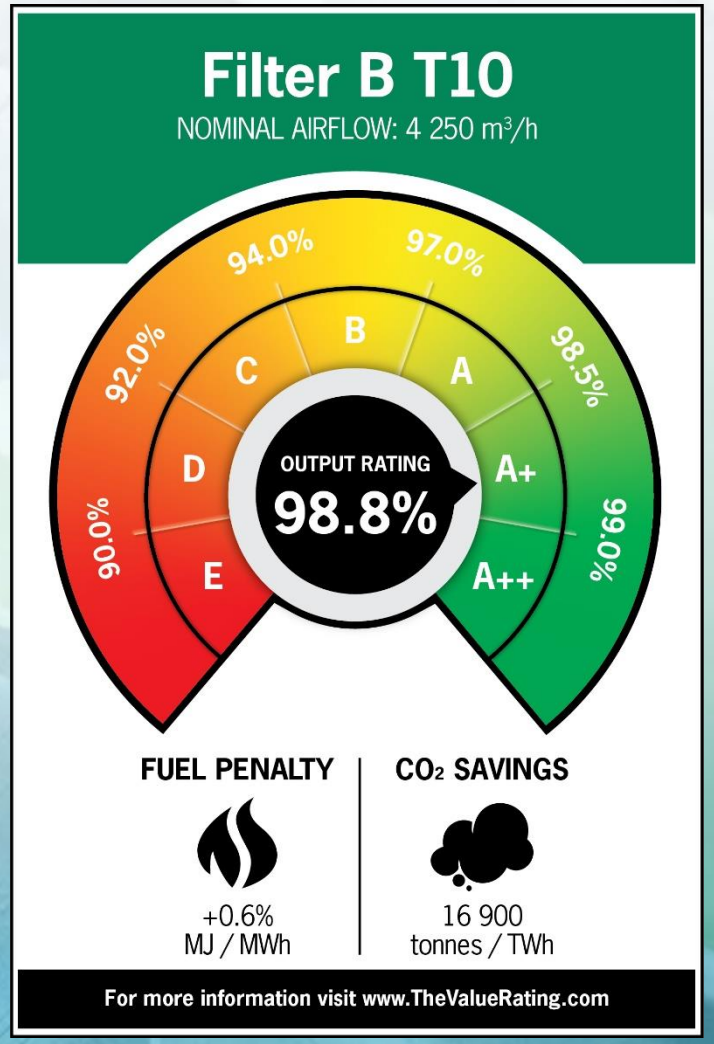
SUSTAINABILITY

FILTER COMPARISON EXAMPLE
SUMMARY

	CamGT 3V-600 T12	Typical T8	Impact
OUTPUT RATING	**99.2 %**	**92.2 %**	+7%
FUEL PENALTY MJ / MWh	**0.4 %**	**3.8 %**	-3.4%
CO_2 SAVINGS tonnes CO_2 / TWh	**17 800**	**3 800**	-14 000 tonnes / TWh

Filter a versus filter b
which filter is better?





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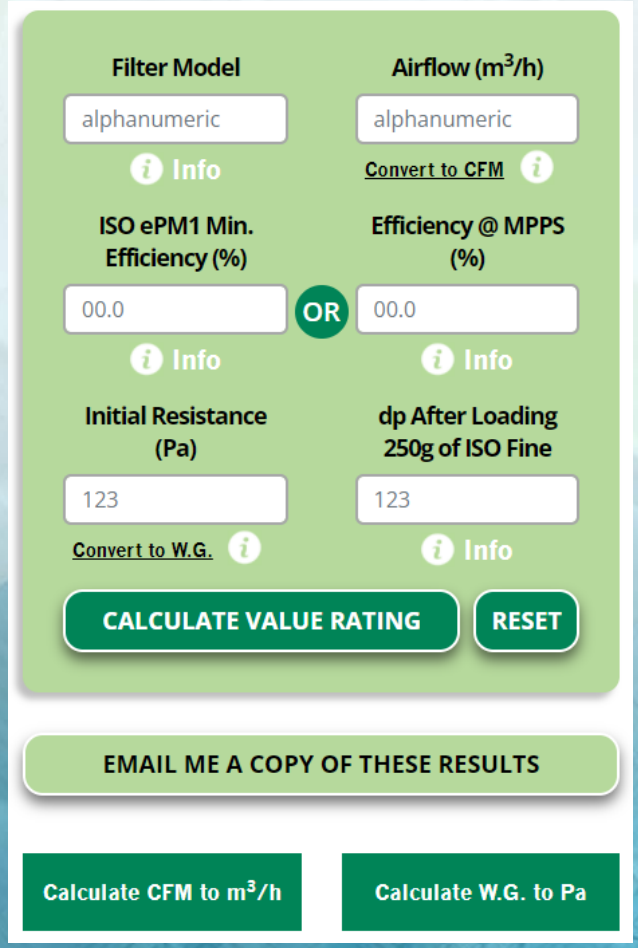
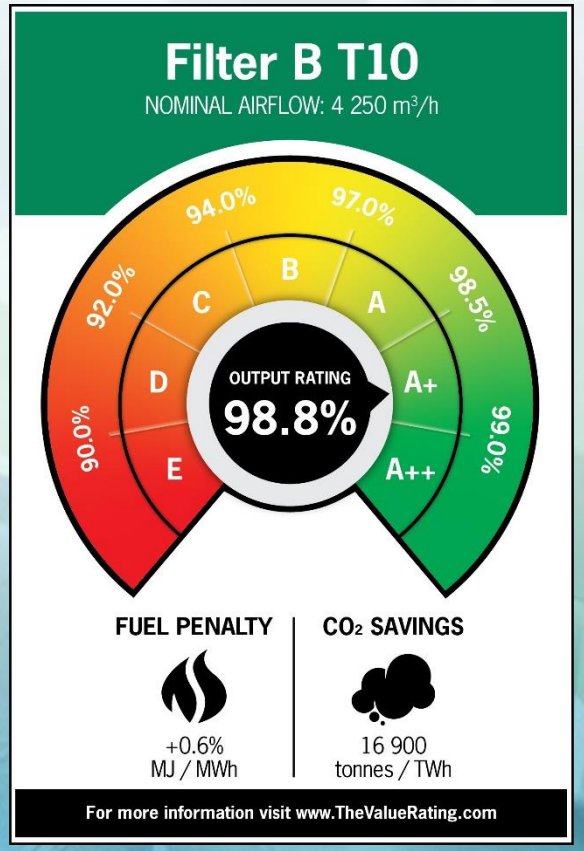
THE VALUE RATING CALCULATOR

Compare any filter for an easy selection at www.TheValueRating.com

Enter Data Here:



See Results Here:



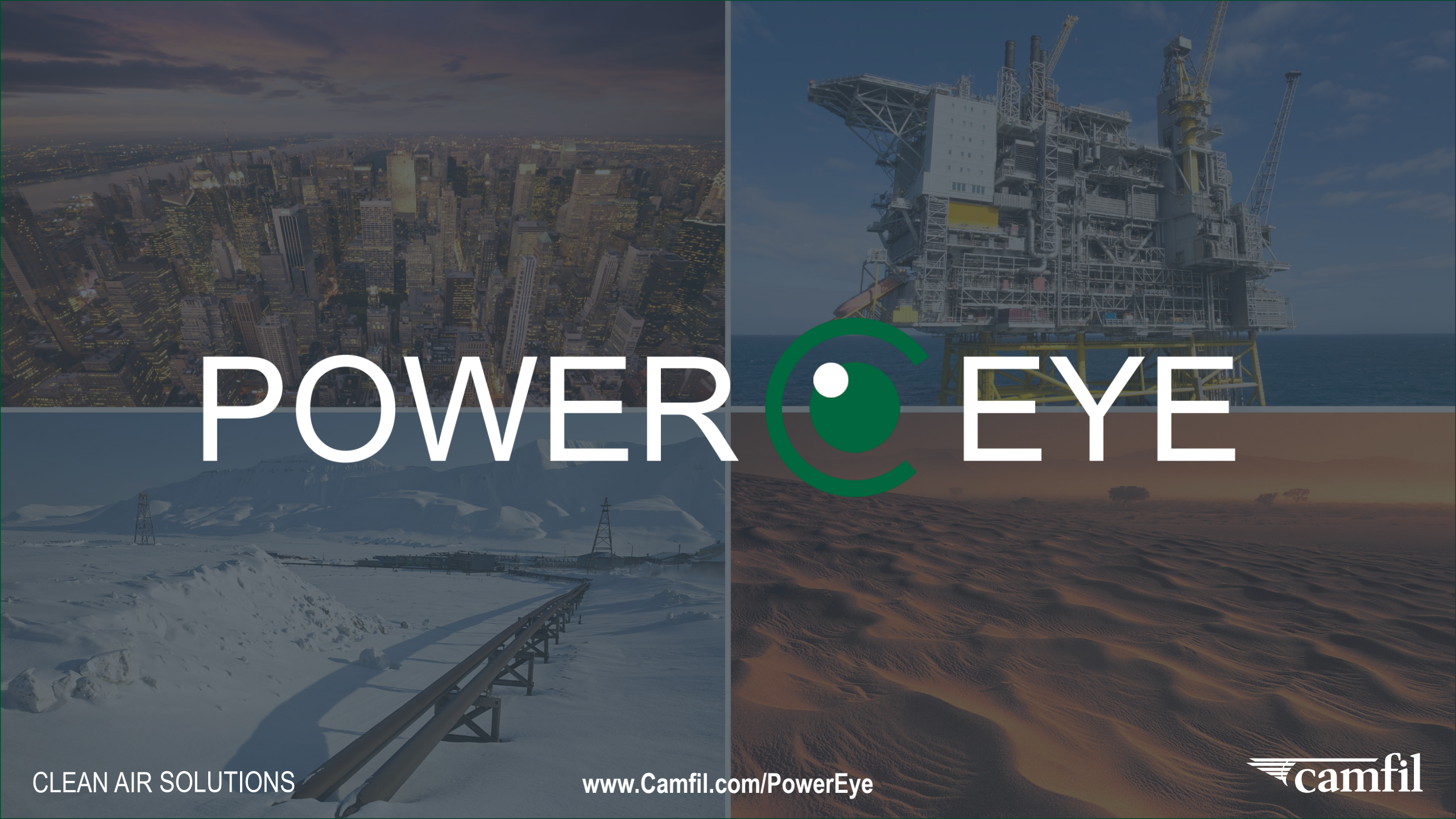
FILTER SELECTION
FURTHER CONSIDERATIONS

The Value Rating helps you quickly calculate the impact of filter efficiency and pressure drop over time on your gas turbine performance. Further considerations should be included when performing a primary filter selection, such as:

- Optimal filter service life should be evaluated through LCC Power
- Filter strength, often measured by the wet burst pressure
- Salt penetration and hot corrosion protection
- Hydrophobic performance, typically measuring dP rise and water penetration during a wet spray test
- For self cleaning filters, filter cleanability

TOTAL COST OF OWNERSHIP

- Capital investment: [CAPEX]
  - Cost of filter housing
  - Installation of housing
- Direct filter costs: [OPEX]
  - Cost of replacement filter elements
  - Transportation to site, installation and disposal
  - Downtime for filter replacement
- Indirect filter costs: [OPEX]
  - Output lost due to pressure drop
- Fouling and thermal corrosion cost: [OPEX]
  - Reduced power output
  - **Increased heat rate/fuel consumption**
  - Water wash consumable cost and downtime
  - **Increased CO_2 emissions per MWh produced**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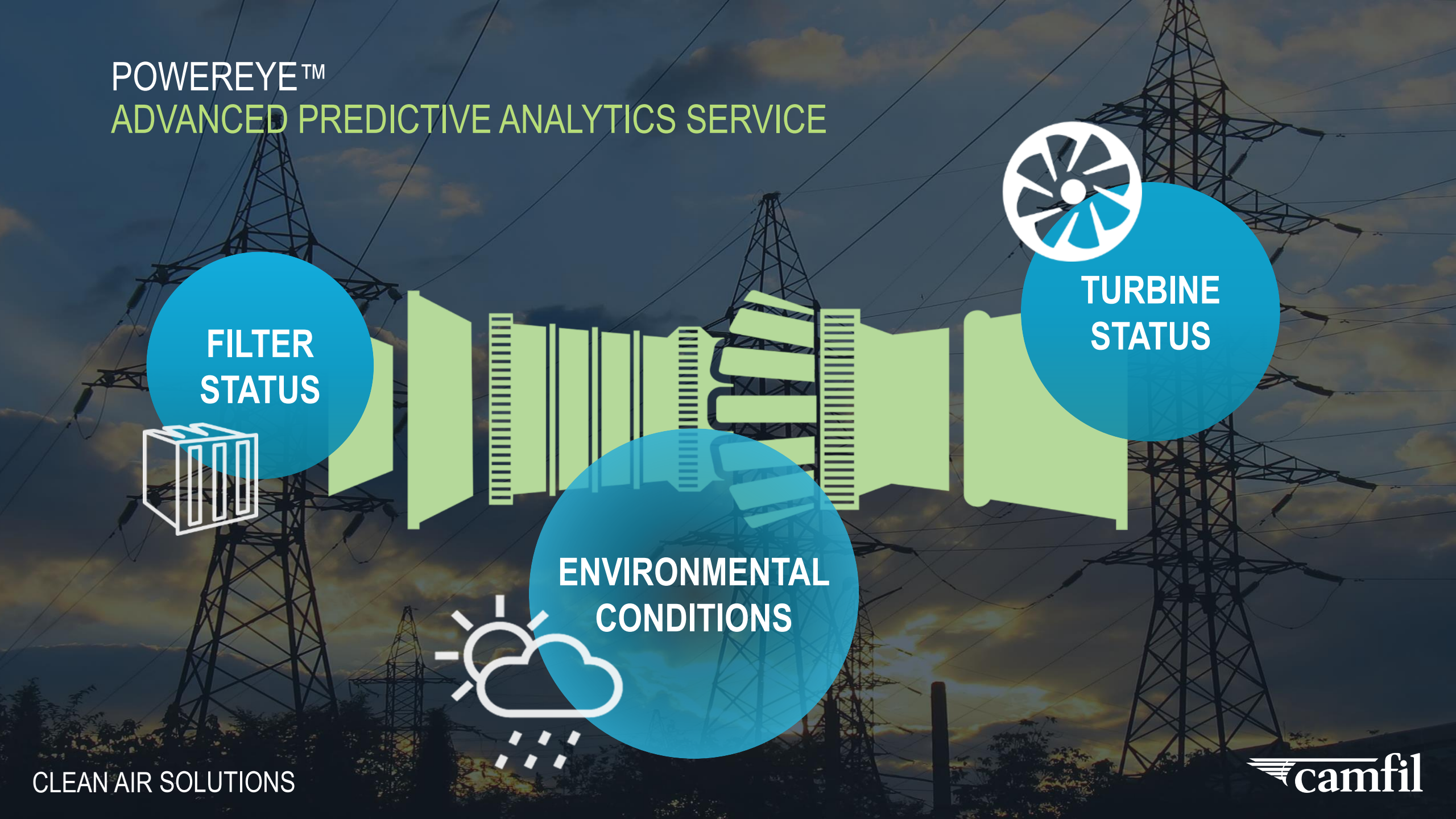
POWEREYE™
ADVANCED PREDICTIVE ANALYTICS SERVICE



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POWEREYE™

- **Ambient condition monitoring**
- **Filter life prediction**
- **Filter change-out optimization (patented)**
- **Filter performance validation**
- Filtration optimization
- Capacity forecasting
- Water wash optimization

QUESTIONS?

Marc Van den Eynde

Vice President– Power Systems

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THANK YOU
FOR YOUR ATTENTION

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