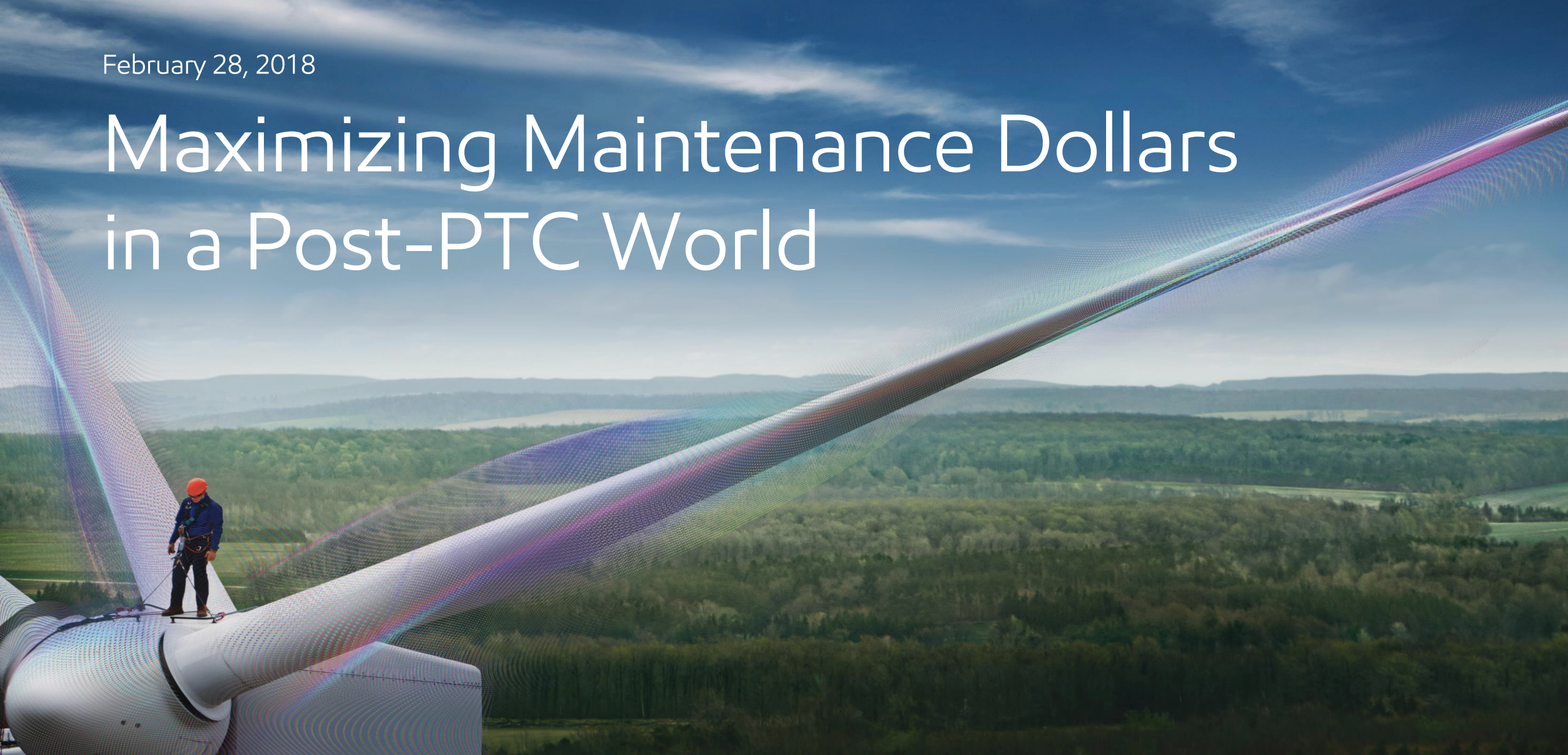


February 28, 2018

Maximizing Maintenance Dollars in a Post-PTC World



What we'll discuss today

- Why the evolving market demands a preventative maintenance approach
- Key elements of a best-in-class preventative maintenance strategy
 - *Regular servicing*
 - *Lubrication*
 - *Used oil analysis*

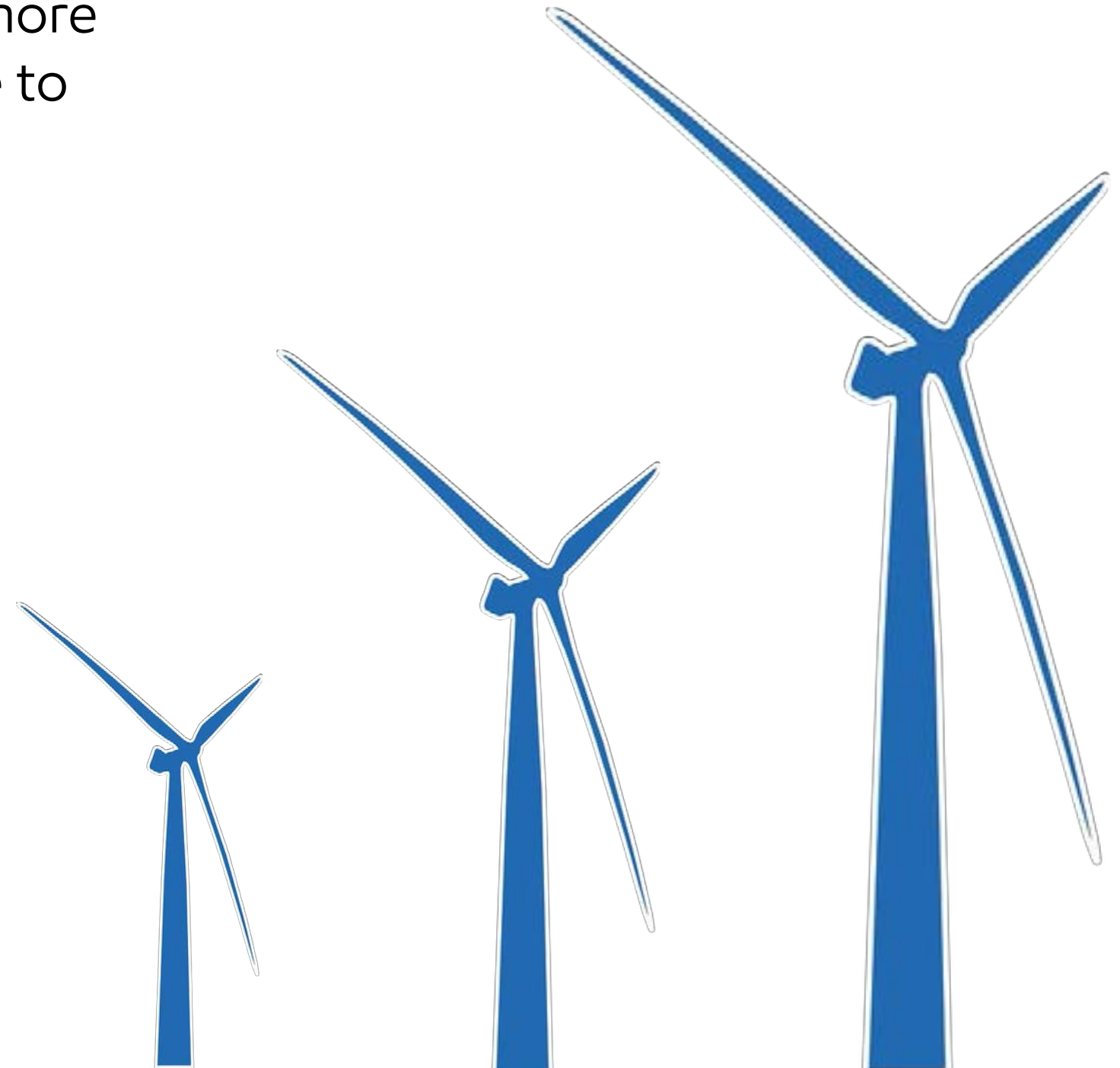
Reminder: O&M is fundamental to a successful operation

Turbines are getting larger and moving to more remote locations, and you need to continue to optimize levelized cost of energy (LCOE).

 **uptime**

 **failure**

 **O&M budget**



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The post-PTC environment will increase pressure on O&M

2019 estimated LCOE*:

- \$34.5/MWh
- Includes \$13.7/MWh cost due to fixed O&M

2022 estimated LCOE*:

- \$44.3/MWh
- Includes \$13.1/MWh cost due to fixed O&M

LCOE is expected to increase by ~30% from 2019 to 2022, while O&M costs will remain about the same.

30%↑



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**For new on-shore wind farms entering service*

Source: https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf

The post-PTC environment will increase pressure on O&M

We're also entering a new, post-warranty era for many wind farm operations – increasing O&M team responsibility even further.

Average age of North American wind fleets:

5.5 years in 2015

7 years in 2020

14 years in 2030



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Source: <https://nawindpower.com/report-om-costs-north-americas-aging-wind-fleet>

The post-PTC environment will increase pressure on O&M

We're also entering a new, post-warranty era for many wind farm operations – increasing O&M team responsibility even further.

The majority of wind turbines installed worldwide are out of warranty*

~370 GW



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Source: <https://www.nrel.gov/docs/fy16osti/65388.pdf>

In this evolving market, downtime is even more damaging

Particularly with LCOE projected to increase in the coming years, any downtime – planned or unplanned – can severely impact your bottom line.

A single gearbox failure can result in:

52% loss in annual energy production

55% increase in unscheduled turbine downtime



What does this all mean?

To maximize
maintenance dollars,
operators need a
preventative
maintenance strategy.

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Benefits of a robust preventative maintenance approach

Meet production commitments.



Minimize downtime.



Optimize safety.



What does a best-in-class approach look like?

Key elements



Smart oil
change
approach



Advanced
lubricants



Routine
monitoring

Planned and thorough oil changes: an essential part of preventative maintenance



When you conduct your oil change matters

- Schedule your oil change in advance
- Schedule for warm weather – 35 degrees Fahrenheit and up
 - Less downtime
 - Cleaner oil changes
- Take advantage of low production months
 - Low wind not no wind
 - Flush cycles require a spin time

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What to look for in a service provider

- Good track record
 - Expertise demonstrated with thorough reports
 - Demonstrated delivery on time and budget
- Expertise to help you plan better and minimize costs
 - Efficient and experienced crew to minimize work time
 - Collaborative with planning – suggests criteria for timing
 - Low rate of repeat oil changes – doing it right the first time
- Is flexible to your needs
 - Commits to delivery on your schedule
 - Ensures they're not overbooked

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Advanced lubrication:
a small change can make a big difference

Lubrication as a first line of defense

Turbines are exposed to some of the harshest conditions in heavy industry:

- Extreme temperatures
- Heavy and varying loads
- Strong winds
- Exposure to water contamination

In these conditions, lubricants are the first line of defense.

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Lubricants protect a range of critical components



Gear oil:

- Gearbox
- Pitch gear
- Open gear
- Yaw gear



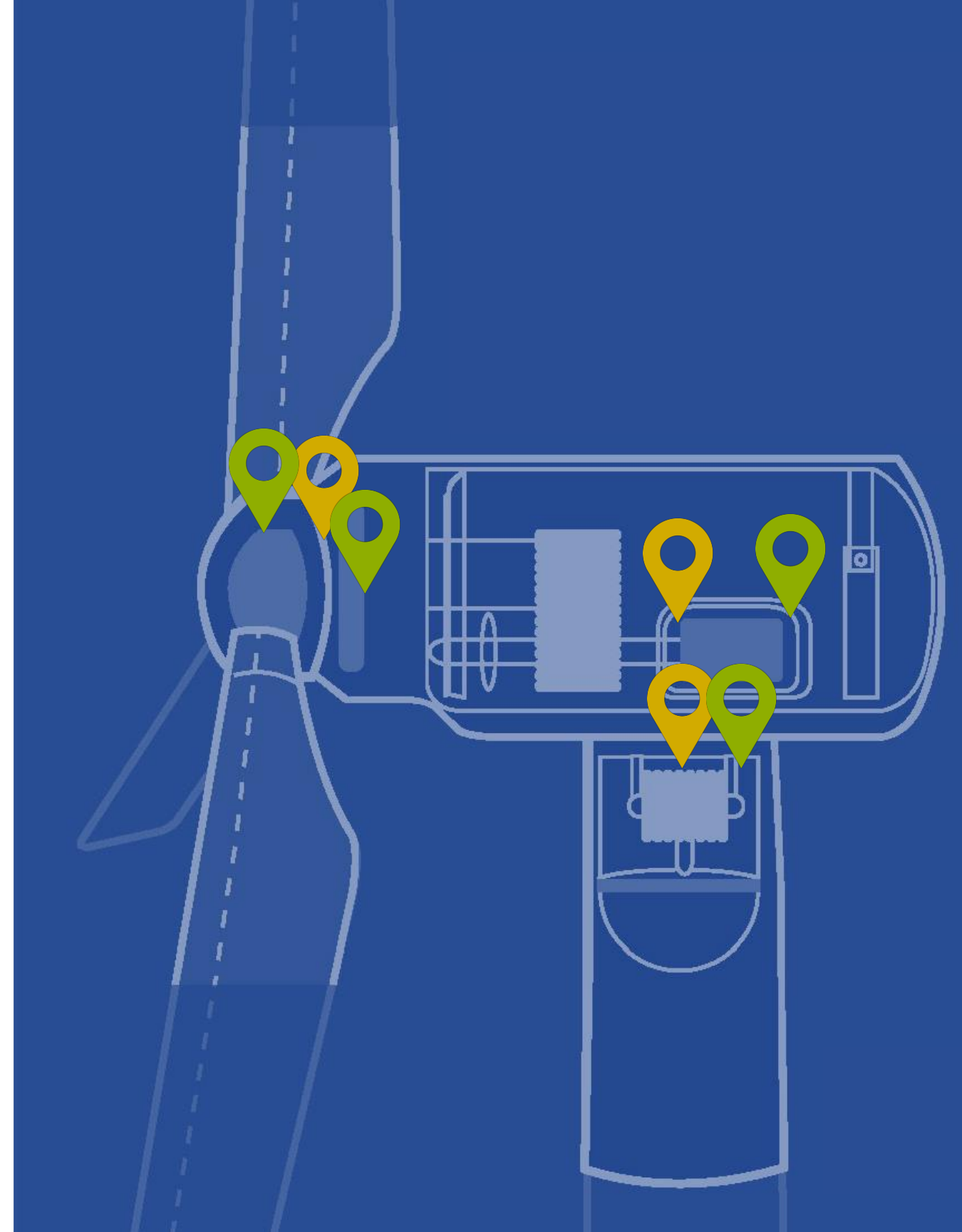
Grease:

- Gearbox
- Pitch gear
- Open gear
- Yaw gear

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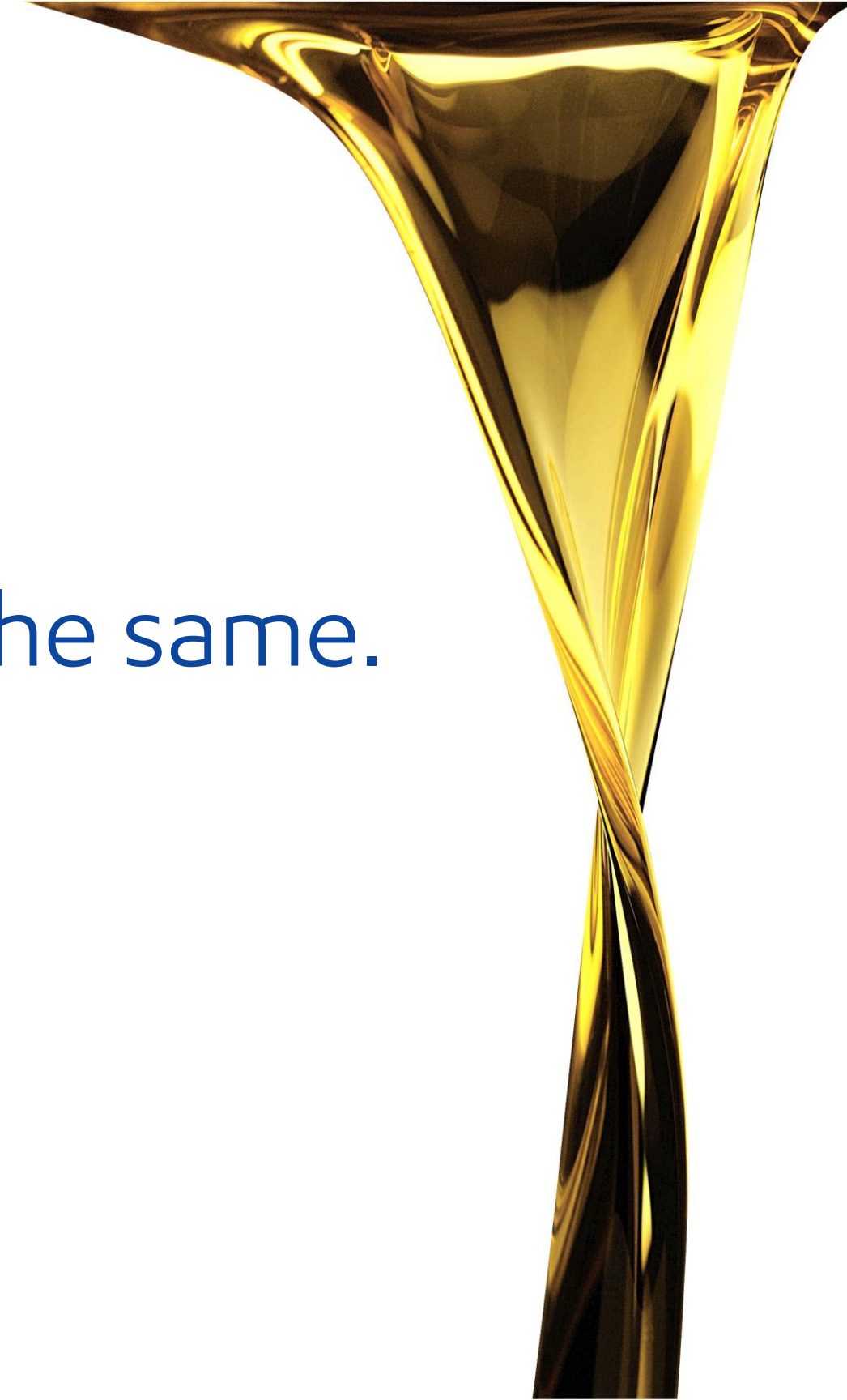


Not all synthetic lubricants are the same.

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Your choice in lubricant matters

- Even for synthetic lubricants, formulation varies significantly.
- Use lubricants formulated with the right mix of advanced base oils and additives.
- They can deliver long-lasting performance and business results.

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Making the right choice can make a significant difference

Switching to an advanced gear oil can help potentially double oil drain intervals.

- Typical wind turbine gear oils have an oil drain interval of 36 months.
- Advanced synthetic lubricants are proven to extend intervals up to 7+ years.
- You could hypothetically eliminate one oil change over 20 years, reducing costs.
- Mitigation methods like top treating won't deliver the same long-term performance.

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What should you look for in a wind turbine gear oil?

Advanced synthetic gearbox oil designed for long life.

- Ability to perform in extreme temperatures (150 degrees Celsius or more)
- Enhanced oxidation and water resistance
- Superb protection against wear and micropitting
- Foam control and trouble-free wet filterability
- Metal-free formulation that does not contribute to WEC



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What should you look for in a wind turbine grease?

Advanced synthetic grease designed for performance in harsh conditions.

- Excellent performance in severe low-temperature conditions (to ensure sufficient flow and facilitate start-up)
- Robust water tolerance
- Enhanced equipment protection from wear, rust and corrosion
- Long lubrication intervals



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Used oil analysis: a critical tool to deliver real-time performance insights

Why used oil analysis can help

- It is the bedrock of any preventative maintenance program.
- The only way to identify turbine reliability issues such as lubricant degradation and component wear prior to critical failure.
- Routine oil analysis is relatively easy to implement with a valuable pay-off in the long-term.

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Getting the right oil analysis insights

Equipment condition

Provides insight into metal wear and component metallurgy

Lubricant condition

Indicates lubricant quality and pinpoints abnormal conditions

Contamination

Assesses presence of contaminants

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Questions?

Thank you

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