FIRETRACE™ International

IN THE LINE OF FIRE

How the threat of wind farm fires is evolving as a result of changes in turbine technology and the climate – and how operators can manage those risks

SUMMARY

This report shares insights from wind industry fire experts about how manufacturers, operators and investors can respond to the evolving threat fire poses to the sector. It also lays down a challenge to the industry to improve its approach to fire risk.

We start by looking at the following risks and the impacts they have on turbine fires:

- **Warming world**
- **Aging turbines**
- **New materials**
- **Offshore giants**
- **Skills shortages**

Following that, we share advice about how you can best manage these risks with a combination of financial and physical measures. These insights come from both the industry experts we interviewed for this report, and fire specialists in Firetrace's own team who can draw from expertise that stretches back to our launch in the 1980s.

INTRODUCTION

The history books of the 2010s have not been written. But when they are, it's difficult to know whether those in the global wind industry will look on them fondly or not.

On one hand, the industry enjoyed a decade of stunning growth. Total wind capacity rose fourfold from 159GW at the start of 2010 to 651GW at the end of 2019, and it is set to achieve 2,110GW by 2030 according to the Global Wind Energy Council. This has been driven by factors including falling costs and the evolution of larger turbines.

But on the other, the industry received many stark reminders of why climate change is a huge concern for the world. Data from the US National Oceanic & Atmospheric Administration and NASA, among others, showed the 2010s was the hottest decade since modern record-keeping started in 1880. There's so much more for wind to do.

We don't yet know how the last decade will be remembered. However, at the start of the 2020s, we can see how those macro trends combine to pose new challenges for companies across this industry. One of these is the changing nature of turbine fires.

OPENING UP ON FIRE DATA

HOW OFTEN DO WIND TURBINES CATCH FIRE?

It feels like this should be an easy question to answer, but there is little rigorous data that insurers or manufacturers share publicly. The numbers we can see vary wildly.

For example, an article in *Wind Power Engineering* magazine in 2020 estimated that one in 2,000 turbines would catch fire, and *Fire Protection Engineering* magazine put the figure at one in 10,000 in 2019. An independent fire expert we spoke to said that the risk of a catastrophic fire (i.e. only fires that destroy the turbine) is one in 15,000.

If one in 2,000 turbines catches fire each year, that suggests that a typical wind farm with 150 turbines would experience one or two fires during 20 years of operation. But the lack of figures that the industry can agree on causes challenges for the industry.

Here are three major challenges:

- **Negative reputation:** By failing to be transparent, the wind industry is leaving the way clear for opponents of the industry to set the agenda for discussion of wind's safety record, and stifles good stories about the progress being made.
- **Operator uncertainty:** The lack of rigorous figures makes it difficult for wind farm owners and operators to decide what level of fire protection they need in order to protect the large investments they are making in their wind farms.
- **Reliance on old data:** Continued use of turbine fire data from the mid-2010s means companies are unable to spot recent fire trends and address them.

This is strange because experts in the safety industry believe that manufacturers and operators are taking fire risk seriously, and see progress is being made. This is both with active fire suppression systems and passive design improvements.

Chris Streatfeild, director at health and safety consultant Forge Risk, said he can

see why the wind industry is cautious about opening up on this data, but adds companies are "fundamentally going in the right direction in terms of health and safety". He says the industry has a good track record on managing fire risk and should be confident.

"I think we need to take data ownership. The industry certainly has opportunities to be better about sharing and communicating data about incidents, because we need to share, and we need to learn from it... I fully understand the industry's caution, but I think we should be more open, more up front and more willing to own the issue."

We expect this report to raise more discussion about evolving fire risks.

EVOLVING FIRE RISKS

In this report, we will look at how that combination of fast growth in the wind industry and the warming planet are both affecting how companies should manage this risk.

For example, the growth of the wind industry, both onshore and offshore, has led to the developments of larger turbines using materials that lead to different fire risks. In addition, the fast growth of wind means there is a growing fleet of older turbines that need to be managed and maintained. Unfortunately, in countries such as the US, the number of technicians needed to do that work has not grown at the same pace.

These would be worthy of analysis even if the planet wasn't warming. We will unpack each of them and explain how they impact on turbine fire risk in the following pages.

However, climate change adds an extra dimension, as it has played a major role in worsening the wildfires that we have seen this year in countries including Australia and the US, most notably California. We have seen the role that wind turbines can play in starting fires on nearby brushland in recent years. A hotter and drier climate can only increase the severity of fires on nearby land, and thus operators' liabilities.

Wind companies must be proactive to manage these emerging risks – and, broadly, we are confident that companies take fire risks seriously. Operators may see them as low-frequency events but they also know that replacing a turbine is expensive. If Covid-19 has taught us anything, it's the need to be ready for rare catastrophes.

FIVE EMERGING RISK FACTORS

For wind farm owners and technicians, the good news is that turbine fires will rarely pose a threat to the lives of the people working in the turbines.

For example, even if a particular turbine had technicians in it for 100 hours per year, that is only 1.1% of the total 8,760 hours the turbine could potentially operate for in that year. The turbine would be shut down for a majority of the 100 hours during service.

If you combine this with the fact that the risk of a particular turbine setting on fire is only one in 2,000 in any given year, that means the threat to life is very low. Firms also have evacuation procedures in place in place at turbines if the worst happens.

There is no room for complacency, but that should be heartening for all the players.

For owners, the bigger threat is financial. It could cost an operator between $1.5M and $3M to install an onshore turbine, but replacing one after a catastrophic fire is likely to cost three or four times that. That could put it in the region of $8M to $9M. These figures apply for turbines currently being installed, not older smaller models.

Therefore, wind farm owners and operators must be aware of how fire risks in their turbines are evolving. We've spoken to a series of industry experts during research for this report, and here are the five biggest challenges that they identified.

1. WARMING WORLD

This year, we've seen devastating wildfires in Australia and the US. These are being exacerbated by climate change, which is raising temperatures and causing droughts.

Those are the perfect conditions for fire, and expose operators to additional risk if the turbines on their site spark an environmental disaster in a much wider area.

Let's look at Pacific Gas & Electric, which in June 2020 emerged from 18 months in bankruptcy protection. It filed for bankruptcy due to multi-billion-dollar liabilities for wildfires that were started in 2019 by its power lines. We must clarify that it wasn't linked to a turbine fire, but reminds us that energy infrastructure is a wildfire risk.

Such wildfires can cause huge environmental and reputational damage, as well as exposing operators to costly damages. In recent years, we have seen examples in the wind industry of where turbines have contributed to similar but smaller fires.

- **Buffalo Gap:** A turbine fire in Texas in August 2019 sparked the 250-acre Rhodes Ranch 3 Fire in Mulberry Canyon.
- **Game Ranch Fire:** A turbine fire in Texas in July 2020 caused a 3,200-acre wildfire in Nolan County.
- **Juniper Canyon:** A turbine fire in southern Washington state in July 2019 ignited the surrounding grass and brush after melted sections fell to the ground. This caused the more-than-250-acre Juniper Canyon wildfire.

These situations can expose operators to legal claims from neighbouring landowners even if there was no negligence by the operator. They can also provoke arguments between insurers, manufacturers and operators, as insurers want to make sure they are only paying out for genuine accidents and not poor machinery or maintenance.

One insurance expert, who didn't want to be named, said it was a particular issue for new models that aren't yet industry standard: "If there's some failure in the unit itself, the insurer will look to the manufacturer to bear some of that cost," he said.

This shows that turbine fires can have far-reaching impacts.

2. AGING TURBINES

The first major wave of turbines installed in the mid-1990s are coming to the end of their operational lives and, overall, around 7% of the current wind fleet is now over 15 years old. That figure is around 28% in Europe due to the maturity of the sector.

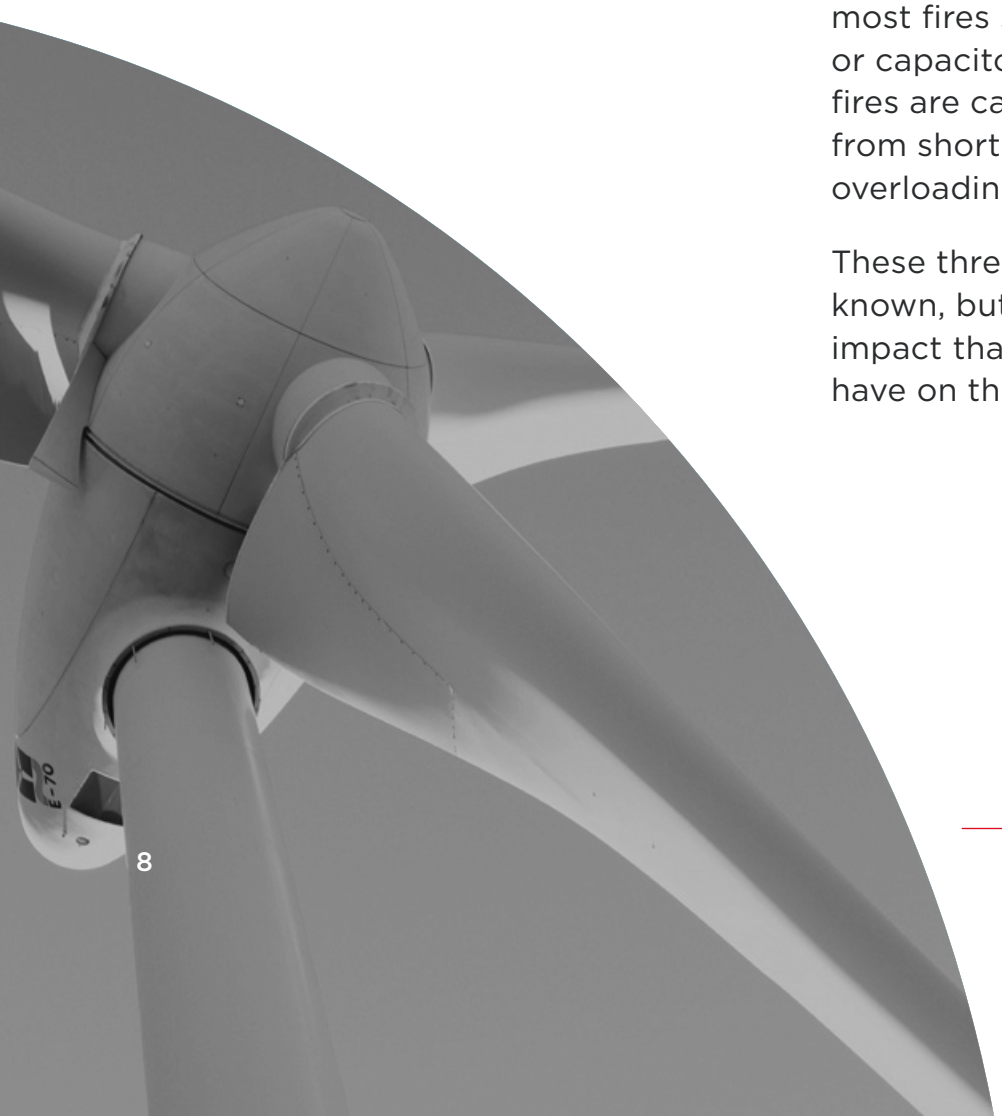
This is likely to raise additional fire risks for operators, although there can be a huge difference in the risks in a particular turbine given how they are maintained. An older turbine that has been well maintained could be a low risk, whereas an older turbine that hasn't been well-maintained, or has a well-known defect, could be high risk.

Essentially, this is not very different from cars. Older models may be less reliable because the technology was less sophisticated, in addition to their age. This can exacerbate problems in the three primary ignition sources in typical turbines:

- **The converter and capacitor cabinets in the nacelle**
- **The transformer**
- **The nacelle brake area**

The hydraulic area is sometimes considered a fourth ignition source. Of these three primary ignition sources, most fires start in the converter cabinet or capacitor cabinet in the nacelle. Most fires are caused by electrical failures, from short circuits or cable failures to overloading or generator problems.

These threats are all relatively well-known, but we don't yet know the impact that the aging turbine fleet could have on the frequency of fires.



3. NEW MATERIALS

The risks with older machines may be well-known. The risks with some materials in new turbines are an altogether different proposition.

One of these is the fiberglass used in blades.

JP Conkwright, turbine fire investigator and assistant professor of fire protection and safety engineering technology at Eastern Kentucky University, explained that making turbine blades out of fiberglass may expose workers to explosive dust during repairs.

He said: “We’re doing a lot of blade repairs. We’re doing a lot of internal blade repairs, and the fiberglass dust is much more explosive than normal dust. We’re inside a confined space, 300 feet in the air, creating fiberglass dust with a grinder.”

Conkwright said he was working with turbine manufacturers to address the issue.

In Europe, the emergence of wooden turbine towers may be a good story from an environmental perspective, but is a development that the safety community should follow closely, including blade lengths that can cause an increased fire risk. Wind’s growth has been driven by innovation and falling costs, but the sector must make sure these materials don’t create additional risks too.

> **“We’re inside a confined space, 300 feet in the air, creating fiberglass dust with a grinder...**

4. OFFSHORE GIANTS

Size also matters offshore.

The largest confirmed offshore wind order is for 13MW Haliade-X machines by GE Renewable Energy at the first two phases of the 3.6GW Dogger Bank complex in UK waters. These machines are as tall as skyscrapers and, as they are many miles from dry land, they pose a different set of risks from those in onshore wind.

At present, the industry is managing them well.

We spoke to G+, the global health and safety organization for offshore wind. It told us there had been no fire incidents at offshore wind farms in 2018, 2019 or the first quarter of 2020, which were its most recent set of statistics.

The risks to life in offshore wind fires are low: the only reason for technicians to be in an offshore wind turbine is for maintenance and, in that case, they are looking for the turbine risks. If a fire breaks out, there is already an escape vessel available; and we also believe the high barriers to entry for offshore contractors protects operators.

However, operators and investors will be very aware that the costs of a catastrophic fire at an offshore wind turbine would be huge. These are major investments that will only get larger as manufacturers race to develop 20MW turbines, and hiring vessels to repair destroyed machines can cost hundreds of thousands of dollars a day.

This is the definition of a ‘low frequency, high cost’ event.

The costs of a catastrophic fire at an offshore wind turbine would be huge

5. SKILLS SHORTAGES

Operators in some countries must be aware of potential impacts of skills shortages among skilled O&M technicians, and thus on potential fire risks.

Let's look at the US. Wind farms totalling 9.1GW were commissioned in the US in 2019 – the third highest year on record – and an extra 4.4GW in the first six months of 2020. There are now more than 60,000 turbines totalling 109.9GW spinning in the US, but only around 7,000 technicians in the US to manage that fleet.

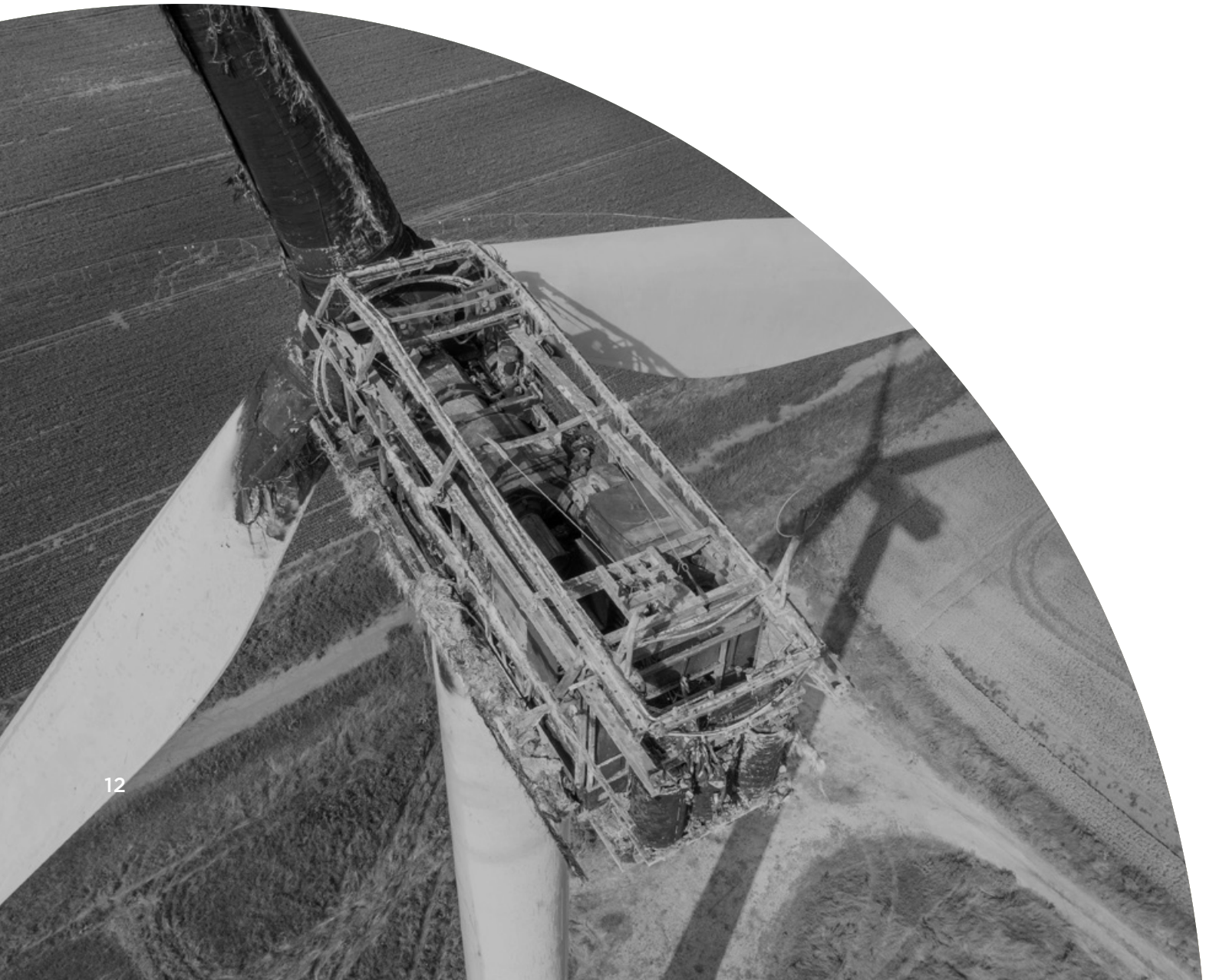
This is prompting O&M specialists to warn of a shortage of skilled technicians.

In addition, operators want contractors to deliver projects cheaper, and are ramping up the pressure on contractors to drive down costs. This is sparking concerns about service quality suffering as contractors seek to carry out O&M at lower prices. Project owners must be vigilant that this doesn't store up extra fire risks in the coming years.

TACKLING THE EMERGING THREATS

These five challenges will affect the ways that operators, manufacturers and others in the wind value chain seek to manage fire risks in turbines.

For operators, this will involve a combination of active fire suppression to stop fires when they have started and insurance to protect them when the worst happens. But they will also look to manufacturers to prevent turbine fires from happening.



DESIGNING OUT RISK

During our conversations with manufacturers, we are confident that companies in the supply chain are taking the threat of fires seriously. Companies appear committed to sharing health and safety best practice across the industry.

In terms of research and development, the main focus is looking at ways to prevent by reducing friction and using different oils, such as hydraulic oils in the turbine pitch control systems. They also want to replace flammable materials with non-flammable materials across the turbine and its associated infrastructure where possible.

However, as an electrical system, fire risk can't be completely removed – and we've already seen earlier how the drive for lighter turbines creates new risks too. There is also a strong focus on evacuation technology if workers do need to exit quickly.

Manufacturers also have to cope with the different fire standards in various markets in which they operate, although our experience is that companies are aiming for the high standards globally. Remember, a turbine fire is a liability for them too, both as a financial cost at a specific project and to their industry reputation for reliability.

This is not solely an issue for manufacturers though.

Operators can also take steps to reduce fire risks in their turbines. This includes by working with skilled technicians that will ensure their turbines are operating safely; picking turbine platforms that adhere to the highest fire safety standards; and taking a proactive approach to installing fire suppression systems before fires do break out.

If they don't then it is their reputation on the line.

If operators don't take steps to reduce fire risks in the their turbines, it is their reputation on the line

THE BENEFITS OF FIRE SUPPRESSION

Operators can use several types of technologies to protect their wind turbines from fires. These include fire detection, arc flash detection, condition monitoring systems and gaseous fire suppression systems. Most focus on preventing fires from starting.

However, only fire suppression systems can help to protect turbines from fires that have already started. For example, our systems target the main ignition sources in turbines, which are in and around the nacelles and transformer areas.

MAIN TYPES OF FIRE SUPPRESSION SYSTEMS

CONVERTER AND CAPACITOR CABINET PROTECTION

Most fires start in the converter cabinet or capacitor cabinet, so most owners protect these areas first.

These hazards can usually be protected with one Firetrace Direct Low Pressure system. The proprietary Firetrace flexible linear heat detection tubing can be routed through the bank of cabinets to quickly detect and deliver FK-5-1-12 suppression agent to the source of a fire.

NACELLE BRAKE AREA PROTECTION

The nacelle brake area is also relatively simple to protect in most wind turbines utilizing a Firetrace Indirect Low Pressure system. When protecting this area, Firetrace flexible linear heat detection tubing detects the fire, and the FK-5-1-12 suppression agent is delivered through separate nozzles.

TRANSFORMER PROTECTION

When protecting a transformer space, Firetrace is able to deliver a robust system with an appropriate amount of FK-5-1-12 to suppress an event. As turbines keep growing, these risks will evolve, and Firetrace has a dedicated team of engineers and business development managers to customize solutions for your application.

WHAT DO I NEED FOR MY TURBINES?

Every customer and turbine platform will be different, but here is a practical guide for the systems you are likely to need – and what you should be looking to spend.

	TURBINE CAPACITY	TURBINE COST	RECOMMENDED INVESTMENT*	RECOMMENDED LEVEL OF PROTECTION
ONSHORE RANGE	1MW	$1M	$ 10,000	Capacitor & Converter Cabinets
	2MW	$2M	$ 20,000	Capacitor & Converter Cabinets Nacelle Brake Area
	3MW	$3M	$ 30,000	Capacitor & Converter Cabinets Nacelle Brake Area Transformer
	4MW	$4M	$ 40,000	Capacitor & Converter Cabinets Nacelle Brake Area Transformer
	5MW	$5M	$ 50,000	Capacitor & Converter Cabinets Nacelle Brake Area Transformer
OFFSHORE RANGE	6MW	$6M	$ 60,000	Capacitor & Converter Cabinets Nacelle Brake Area Transformer
	7MW	$7M	$ 70,000	Capacitor & Converter Cabinets Nacelle Brake Area Transformer
	8 MW	$8M	$ 80,000	Capacitor & Converter Cabinets Nacelle Brake Area Transformer

*Based on cost of a wind turbine, rate of fire at 1 in 2,000 per year, and typical turbine lifetime of 20 years.

CONCLUSION

Fire doesn't stand still. Neither should your approach to fire protection.

It's true to say that many of the fire risks in turbines are the same as they have ever been. A wind turbine is a power generator on top of a tall tower with access to large amounts of oxygen. That won't change and most operators take steps to manage it. When a turbine fire takes hold then it's impossible for firefighters to extinguish it.

However, the changes that we are seeing in the fleet – both in old and new turbine platforms – as well as challenges with technicians and the warming world are raising new challenges that you can prepare for. It's impossible to ever completely eliminate fire risk in your turbines, but it's sensible to try to when the costs can be so large.

Installing fire suppression systems at the three main ignition sources we identified on page 14 costs on average $26,000, which is less than 1% of the average installation cost of a 3MW onshore wind turbine. It is less than 0.6% of the $4.5M that insurance broker GCube says is the average cost of a wind turbine – and exponentially smaller than the financial impacts of some of the wildfires we've seen in recent years.

It's an approach that makes sense for individual operators.

When a turbine fire takes hold, it's impossible for firefighters to extinguish it

A HEALTHY INDUSTRY

For us, though, there is a bigger issue at stake.

We see the work that companies in this industry do on fire risk. This includes work in their own research and development teams, and in collaboration with others across the wind value chain. Yes, we know there are emerging risks to be managed, but we are confident that companies see the safety of workers and communities as central.

Fundamentally, the industry has a good story to tell. Turbine fires are a rarity and the safety record of wind compares favourably with other parts of the energy sector.

Why then do manufacturers and operators so rarely talk about this story? Why is it so hard to find rigorous fire data to back up this story? All too often, the discussion about fire risk in wind turbines is dominated by critics of the sector. But the industry has a strong record and is seeking to make further improvements every year.

These are the stories that we should be talking about.

Nobody wants to be the one hit by a one in 2,000 turbine fire. We see why operators don't want to publicize those incidents. But the whole industry should look to do what it can to shout about the positives too. This will boost its appeal to communities and policymakers, improve its 'social license to operate', and unlock further investment.

So, let's discuss. Let's share more data. And if there are challenges that we need to address, let's do that together. Letting critics set the terms of the debate tells people that we're worried – when, in reality, we should be confident. Talking about the risks discussed in this report can only help us to address them more quickly.

It is with this assured spirit that wind will thrive in the 2020s and beyond.

Would you like to talk about the risks in this report? How about your approach to fire risk in your portfolio?

Get in touch with the Firetrace team today.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