

# Monitoring large wind farms in cold climate

21<sup>st</sup> April 2022  
Simon Grenholm



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# Monitoring large wind farms in cold climate

- Large wind farms... challenges and opportunities
- Stacked views... presenting large data sets for the human eye
- Optimization of Ice Mitigation Systems... collaborative work in MB Ett wind farm



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# Large wind farms...



## ...challenges and opportunities



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# Challenges



- **Keeping the individual focus**





# Challenges

- Keeping the individual focus
- Enormous amount of data. What is important and what is not?





# Challenges



- **Keeping the individual focus**
- **Enormous amount of data. What is important and what is not?**
- **Monitoring becomes time consuming**





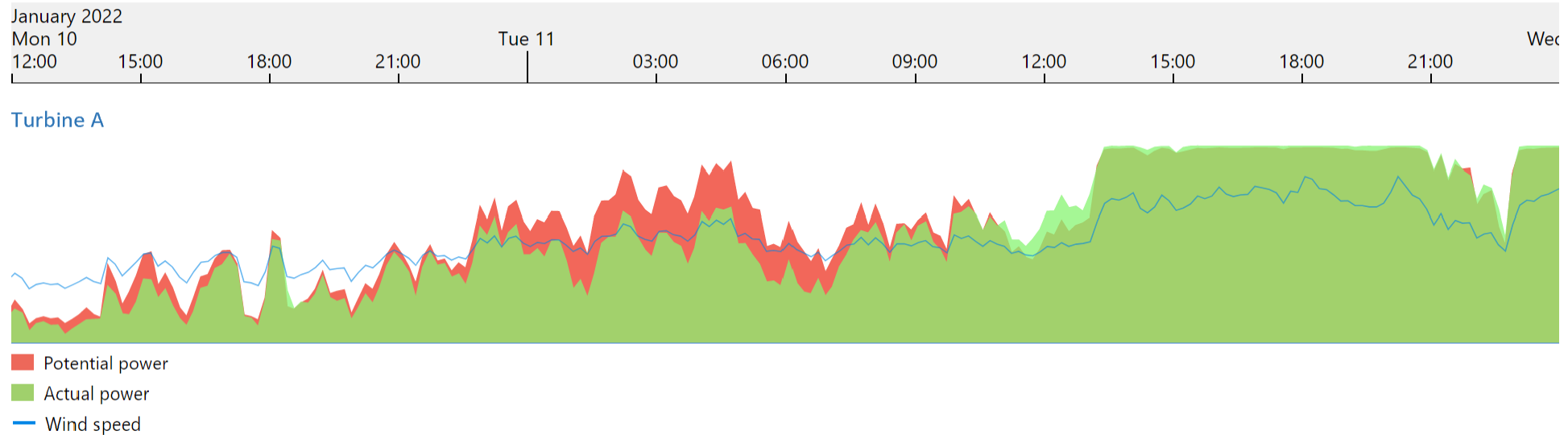
# Opportunities

- Find patterns
- Compare driving forces
- Highlight repeated/systematic faults
- Fine tune settings
- Adjust control systems
- Proactiveness
- Individual focus and care



# Icing event

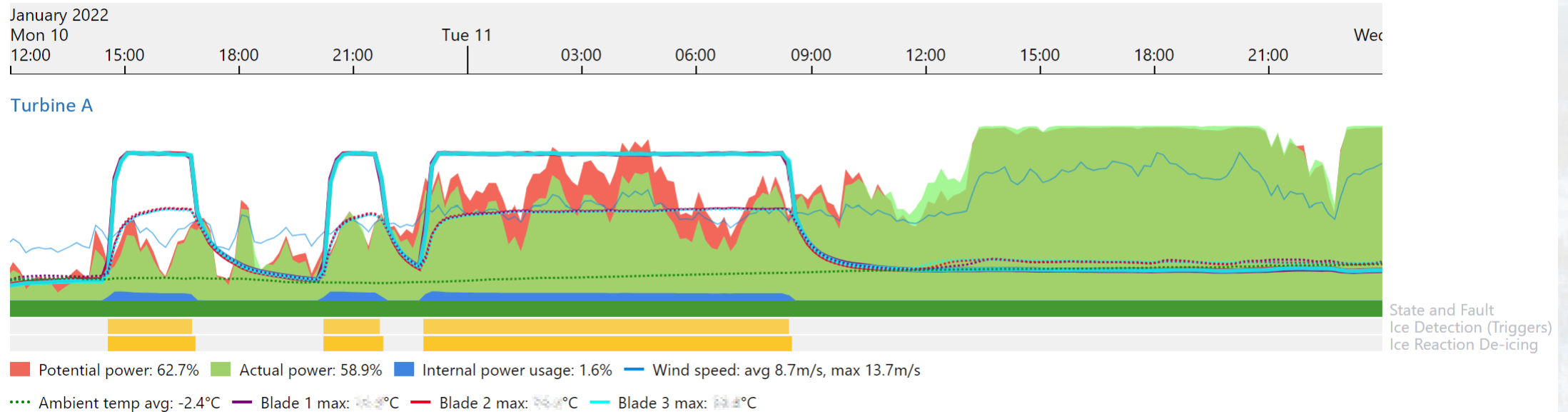
## Is this turbine performing well?





# Icing event

## Is this turbine performing well?



## Add more information...!?

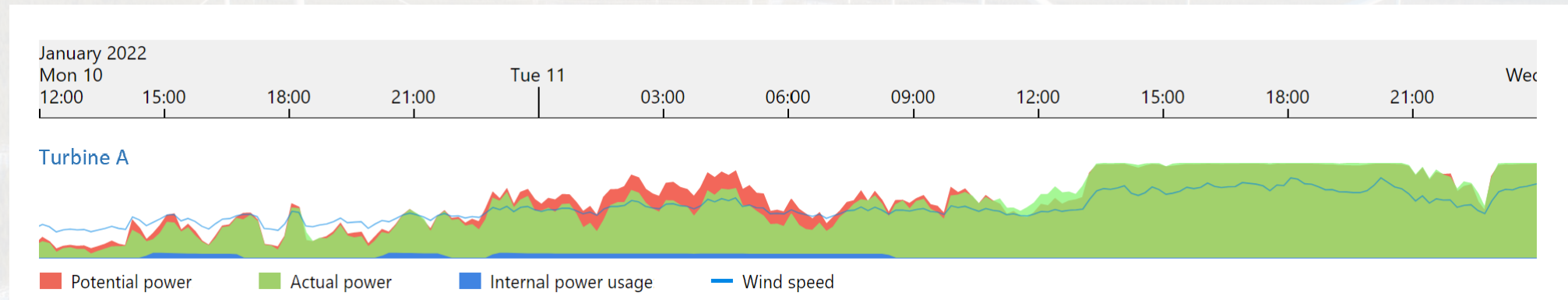


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# Icing event

## Is this turbine performing well?

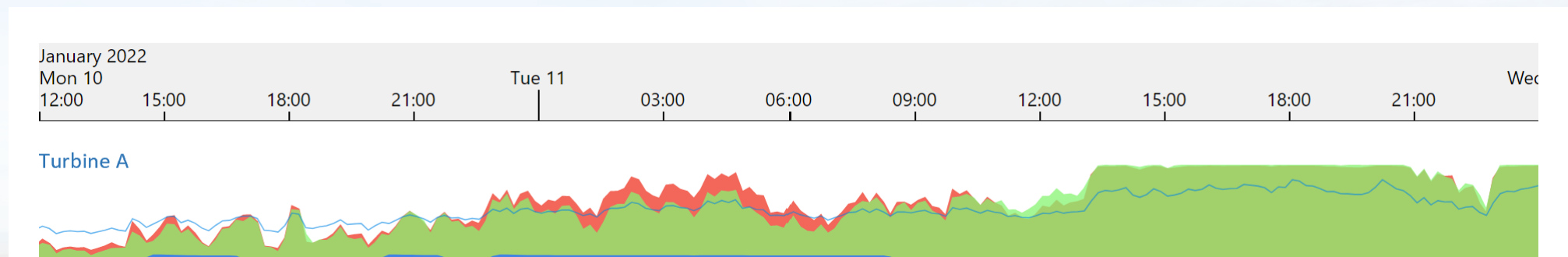


Simplify...



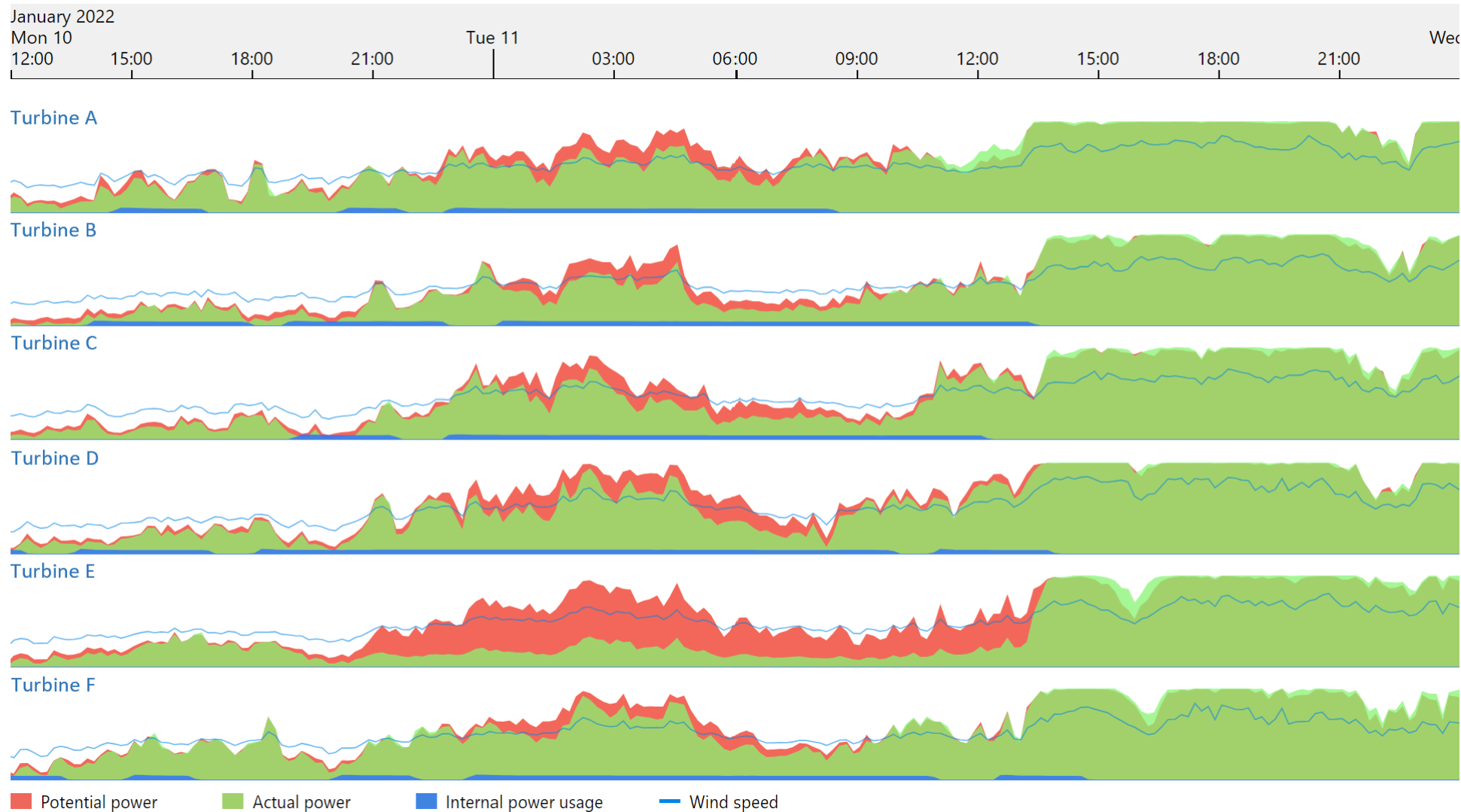
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... and ...



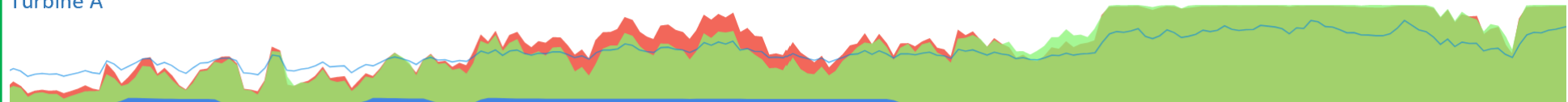


... show neighbours!

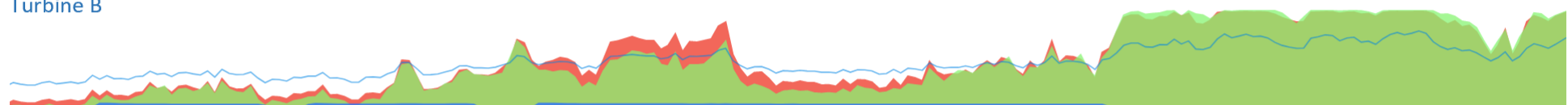


January 2022  
Mon 10 12:00 15:00 18:00 21:00 Tue 11 03:00 06:00 09:00 12:00 15:00 18:00 21:00 Wed

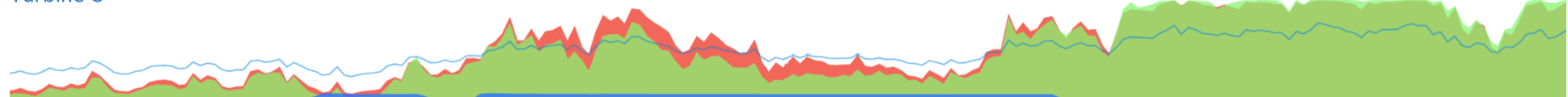
Turbine A



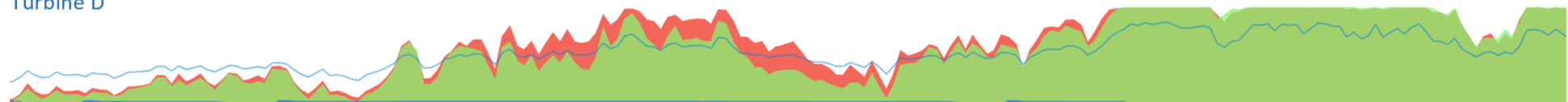
Turbine B



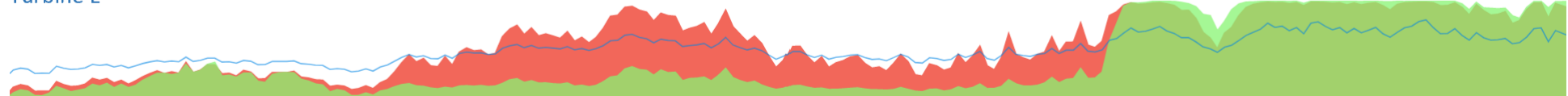
Turbine C



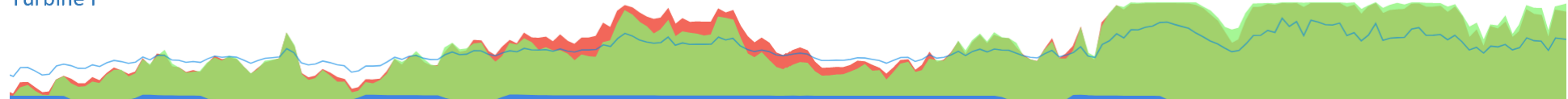
Turbine D



Turbine E



Turbine F



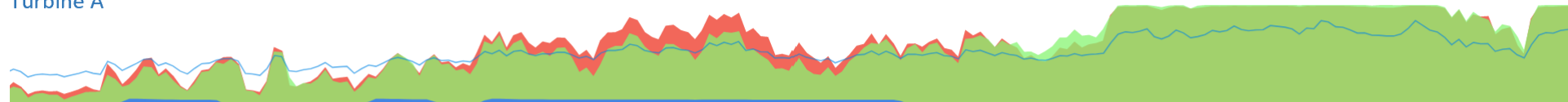
■ Potential power ■ Actual power ■ Internal power usage — Wind speed



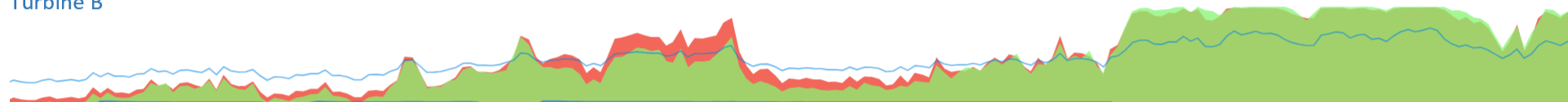


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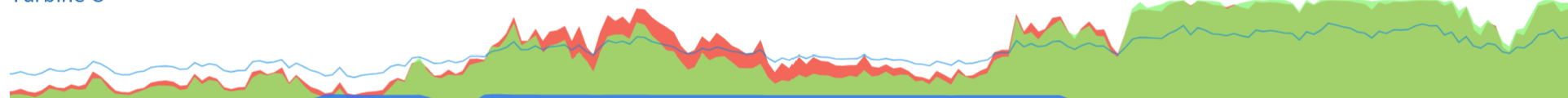
Turbine A



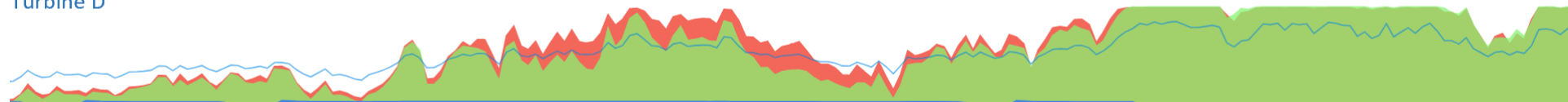
Turbine B



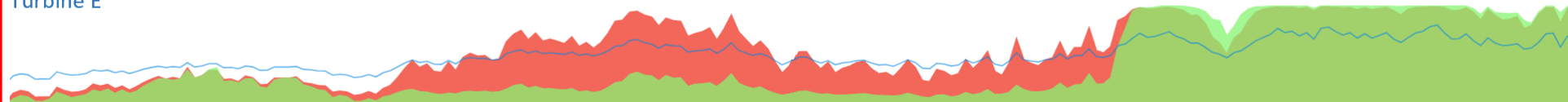
Turbine C



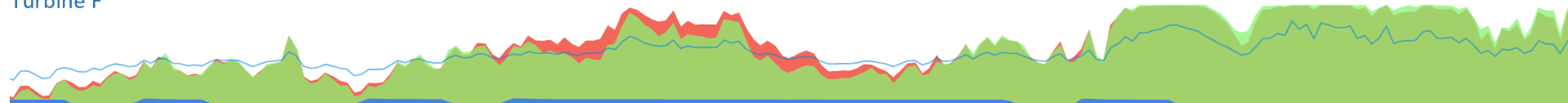
Turbine D



Turbine E



Turbine F



Potential power Actual power Internal power usage Wind speed



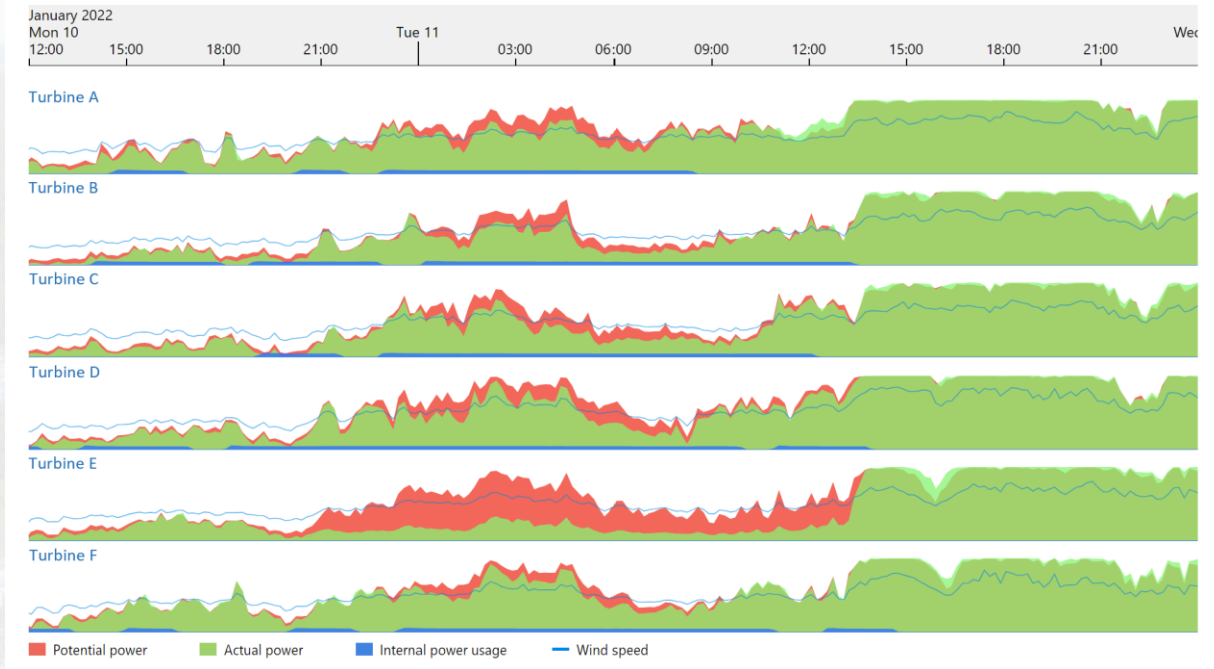
# Traditional AI data analyse



- **Clever black box**
- **Data in**
- **Results out**
- **Need to know which black box to use**
- **Need to know what we are looking for**

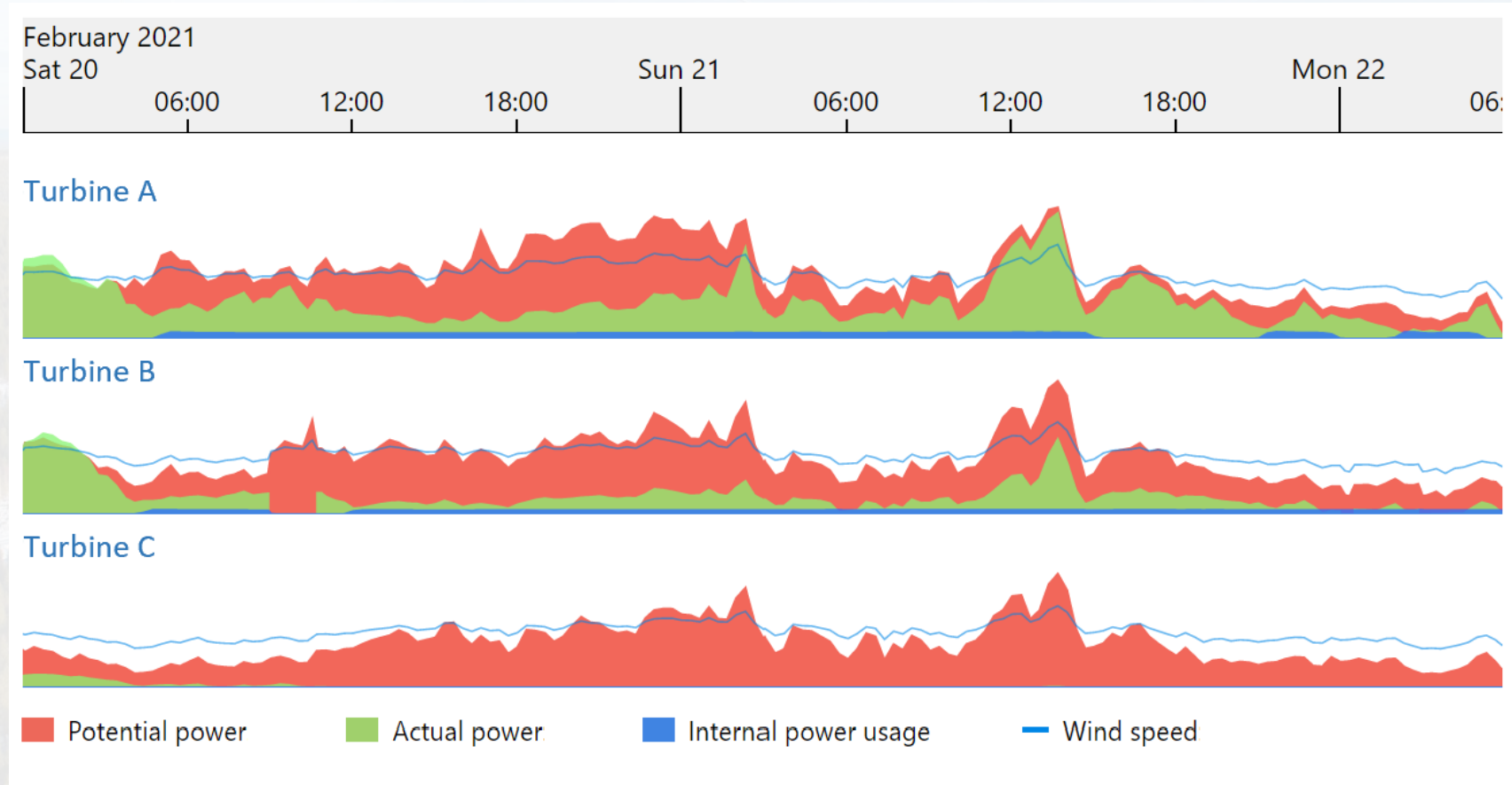


# Stacked views



- Few signals from each turbine
- Show neighbours
- The human eye will see the patterns
- Focus on important issues
- Unexpected findings
- Fast workflow

# Unexpected findings



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February 2021

Sat 20

06:00

12:00

18:00

Sun 21

06:00

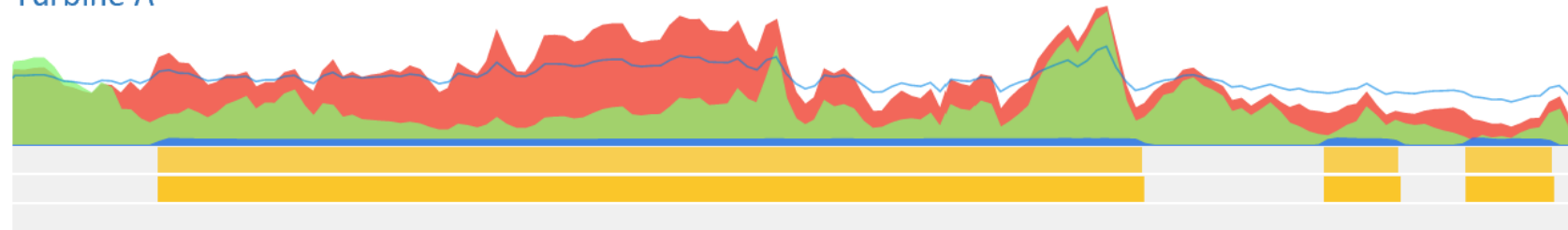
12:00

18:00

Mon 22

06:00

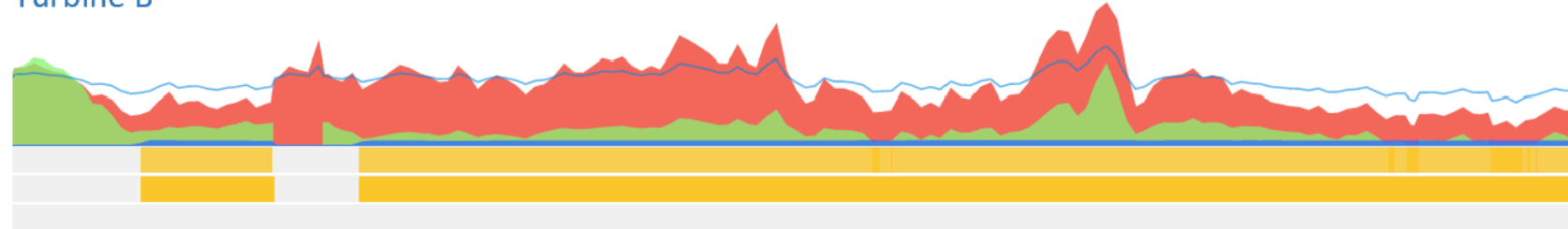
### Turbine A



..... Ambient temp avg: -10.2°C    Blade 1 max: 28.7°C    Blade 2 max: 28.2°C    Blade 3 max: 28.7°C

Ice Detection (Triggers)  
Ice Reaction De-icing  
BHS Faults

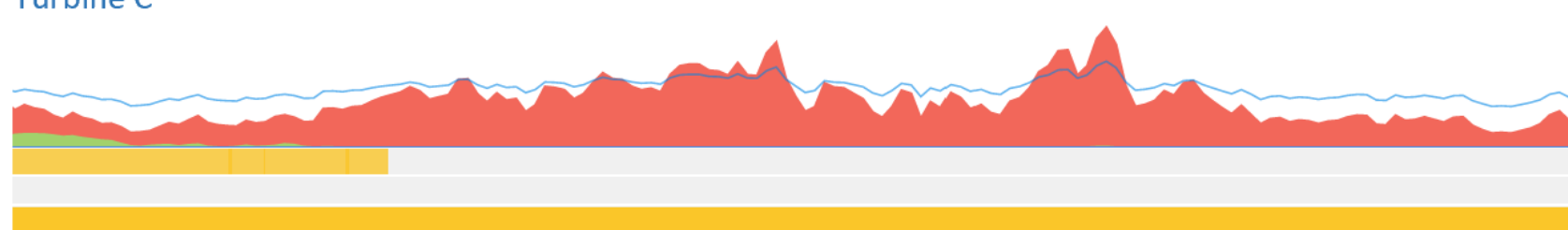
### Turbine B



..... Ambient temp avg: -9.9°C    Blade 1 max: 28.0°C    Blade 2 max: 28.0°C    Blade 3 max: 28.0°C

Ice Detection (Triggers)  
Ice Reaction De-icing  
BHS Faults

### Turbine C



..... Ambient temp avg: -10.1°C    Blade 1 max: 28.2°C    Blade 2 max: 28.2°C    Blade 3 max: 28.2°C

Ice Detection (Triggers)  
Ice Reaction De-icing  
BHS Faults

Potential power

Actual power

Internal power usage

Wind speed



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February 2021

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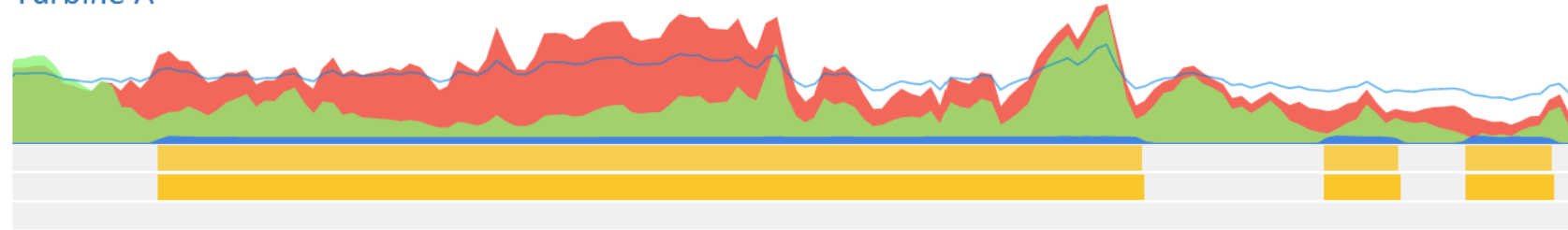
12:00

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Mon 22

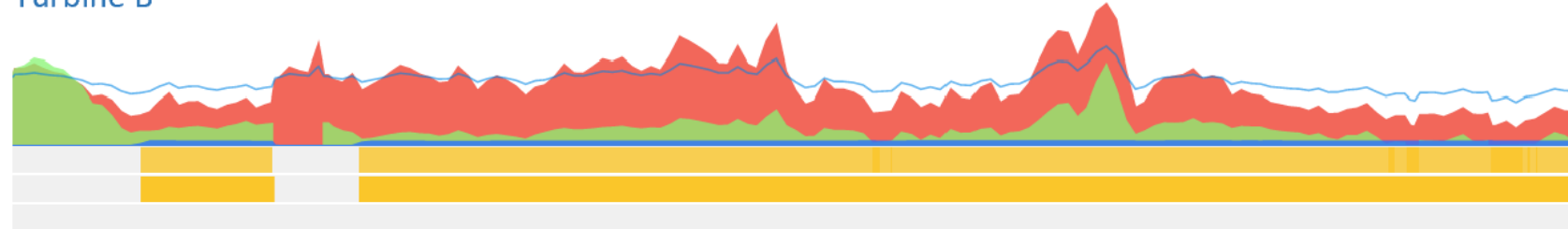
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### Turbine A



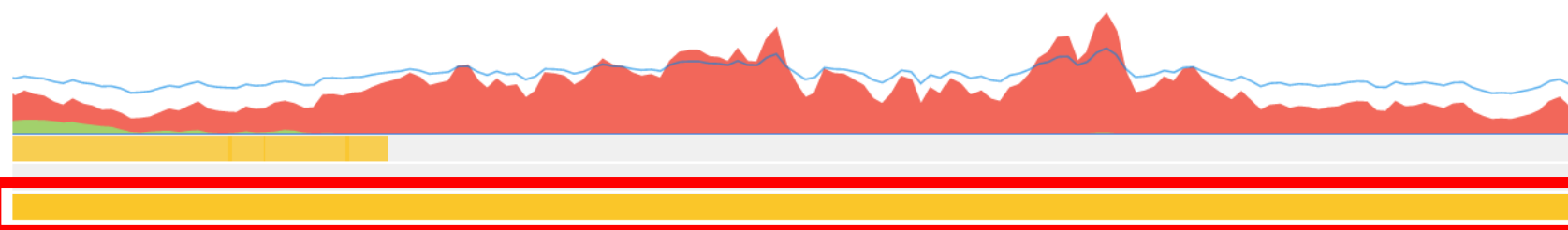
..... Ambient temp avg: -10.2°C    Blade 1 max: 30.7°C    Blade 2 max: 30.5°C    Blade 3 max: 30.7°C

### Turbine B



..... Ambient temp avg: -9.9°C    Blade 1 max: 30.0°C    Blade 2 max: 31.0°C    Blade 3 max: 30.0°C

### Turbine C



..... Ambient temp avg: -10.1°C    Blade 1 max: 30.0°C    Blade 2 max: 30.0°C    Blade 3 max: 30.0°C

Potential power    Actual power    Internal power usage    Wind speed



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February 2021

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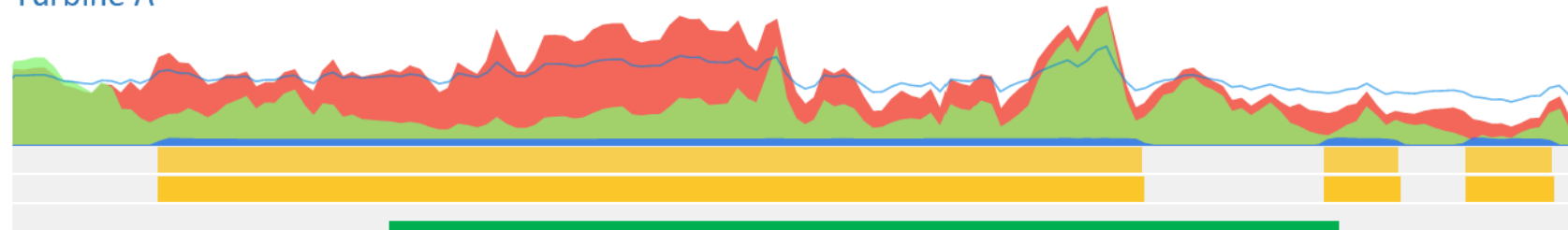
12:00

18:00

Mon 22

06:00

### Turbine A

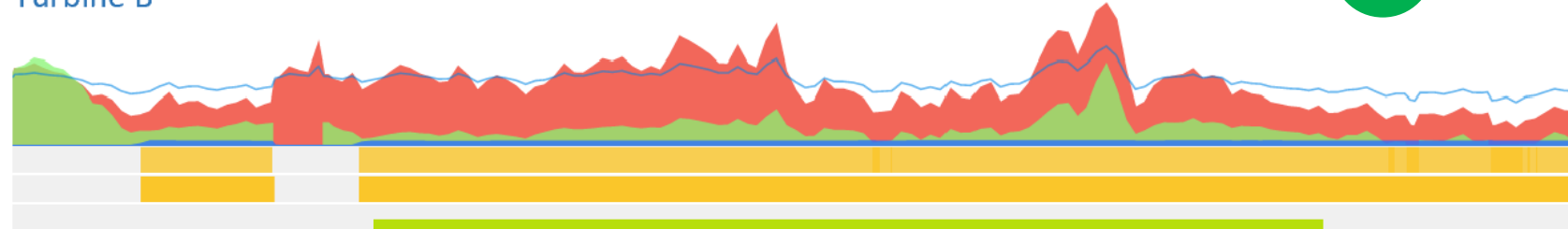


..... Ambient temp avg: -10.2°C

— Blade 1 max: 30.7°C — Blade 2 max: 30.5°C — Blade 3 max: 30.7°C



### Turbine B

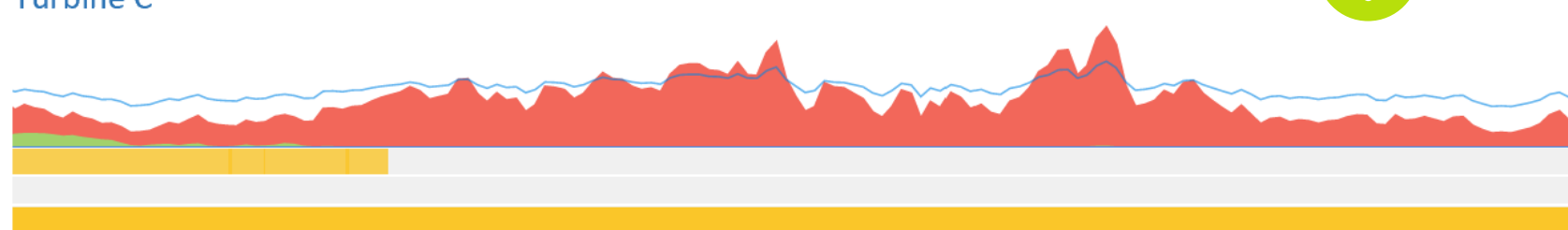


..... Ambient temp avg: -9.9°C

— Blade 1 max: 30.0°C — Blade 2 max: 31.0°C — Blade 3 max: 30.0°C



### Turbine C



..... Ambient temp avg: -10.1°C

— Blade 1 max: 30.0°C — Blade 2 max: 30.0°C — Blade 3 max: 30.0°C

■ Potential power

■ Actual power

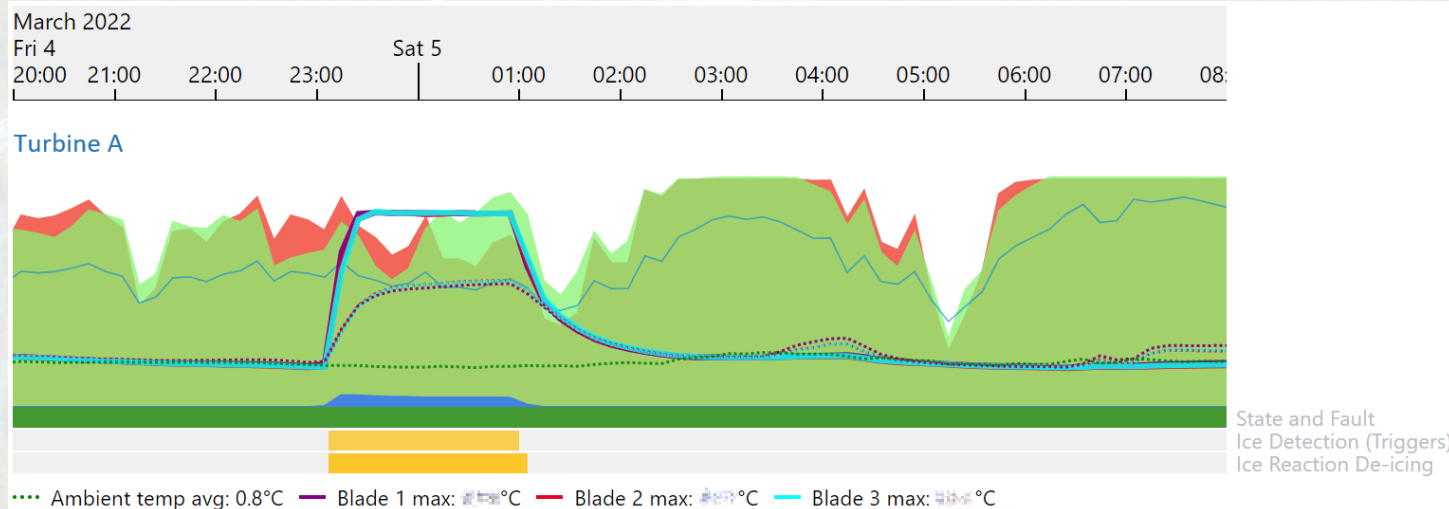
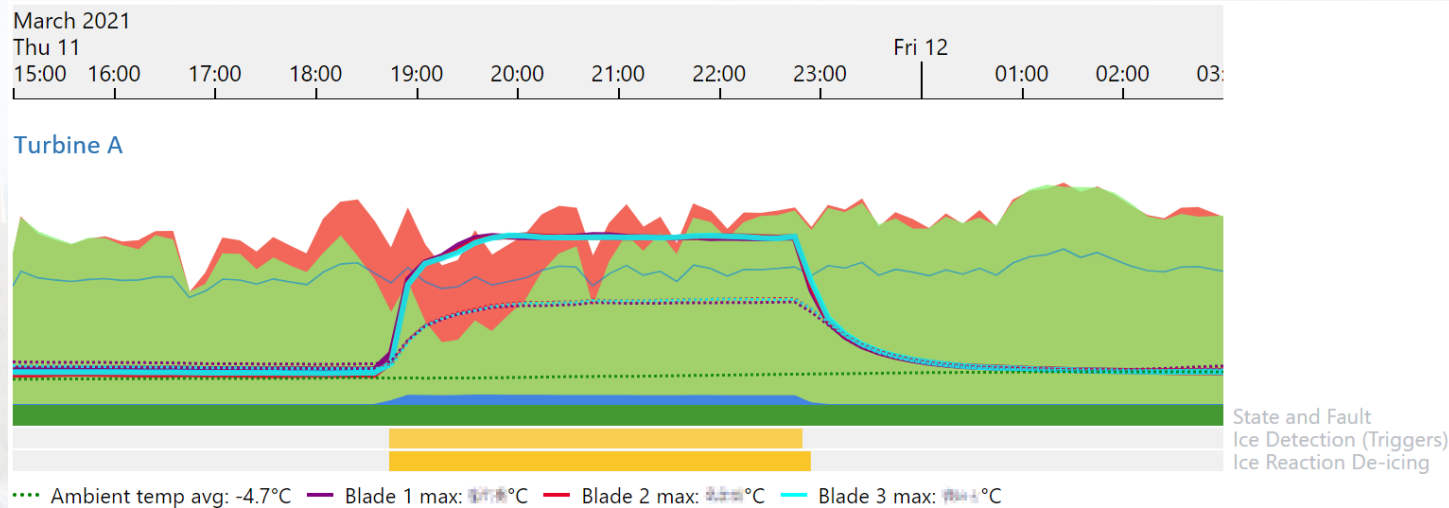
■ Internal power usage

— Wind speed



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# Temperature + Timing



Same turbine...

Previous winter

- Slower response
- Slower temperature rise
- Lower max temperatures

This winter

- Faster response
- Faster temperature rise
- Higher max temperatures
- Reduced ice losses

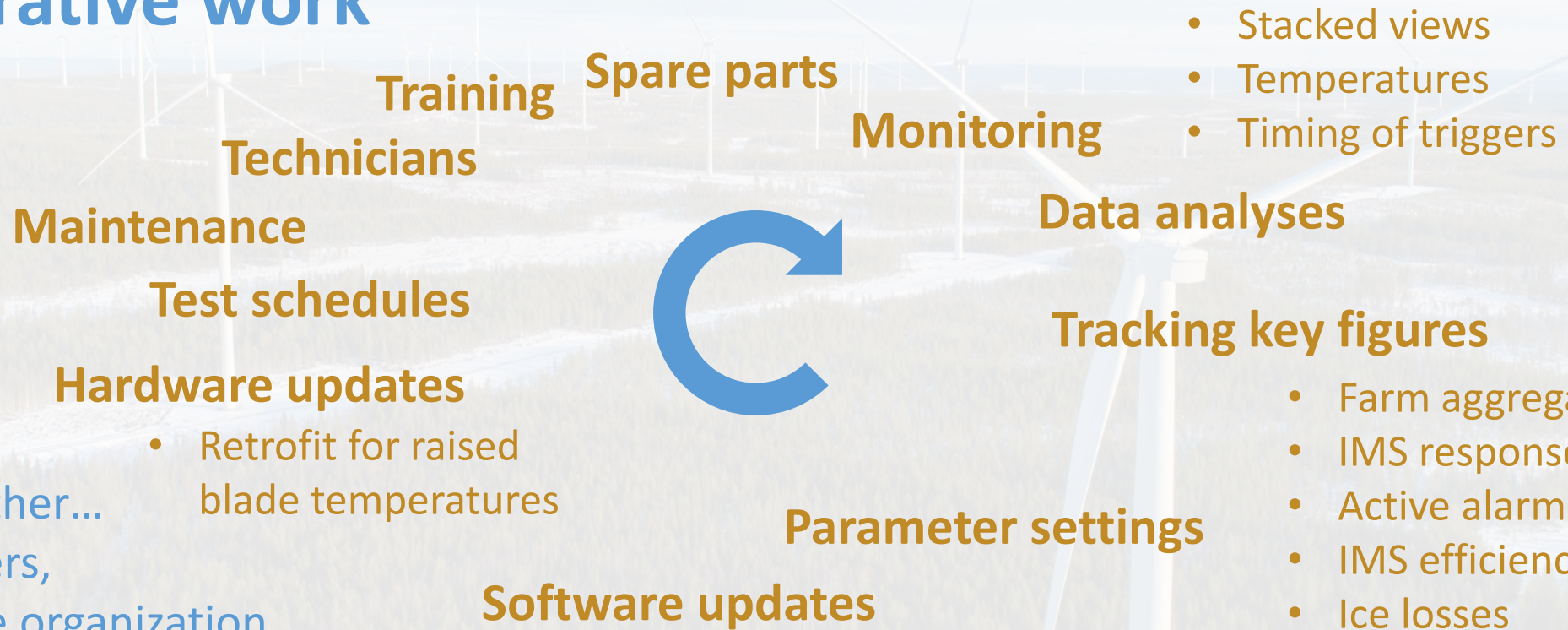


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# Optimization of IMS in MB Ett wind farm

## Collaborative work



Bringing together...

- manufacturers,
- maintenance organization,
- owners,
- data analysts,
- programmers,

... for collaborative meetings, handling challenges and finding opportunities



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# Thank you!

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