



Seasonal Variation of Power Curves

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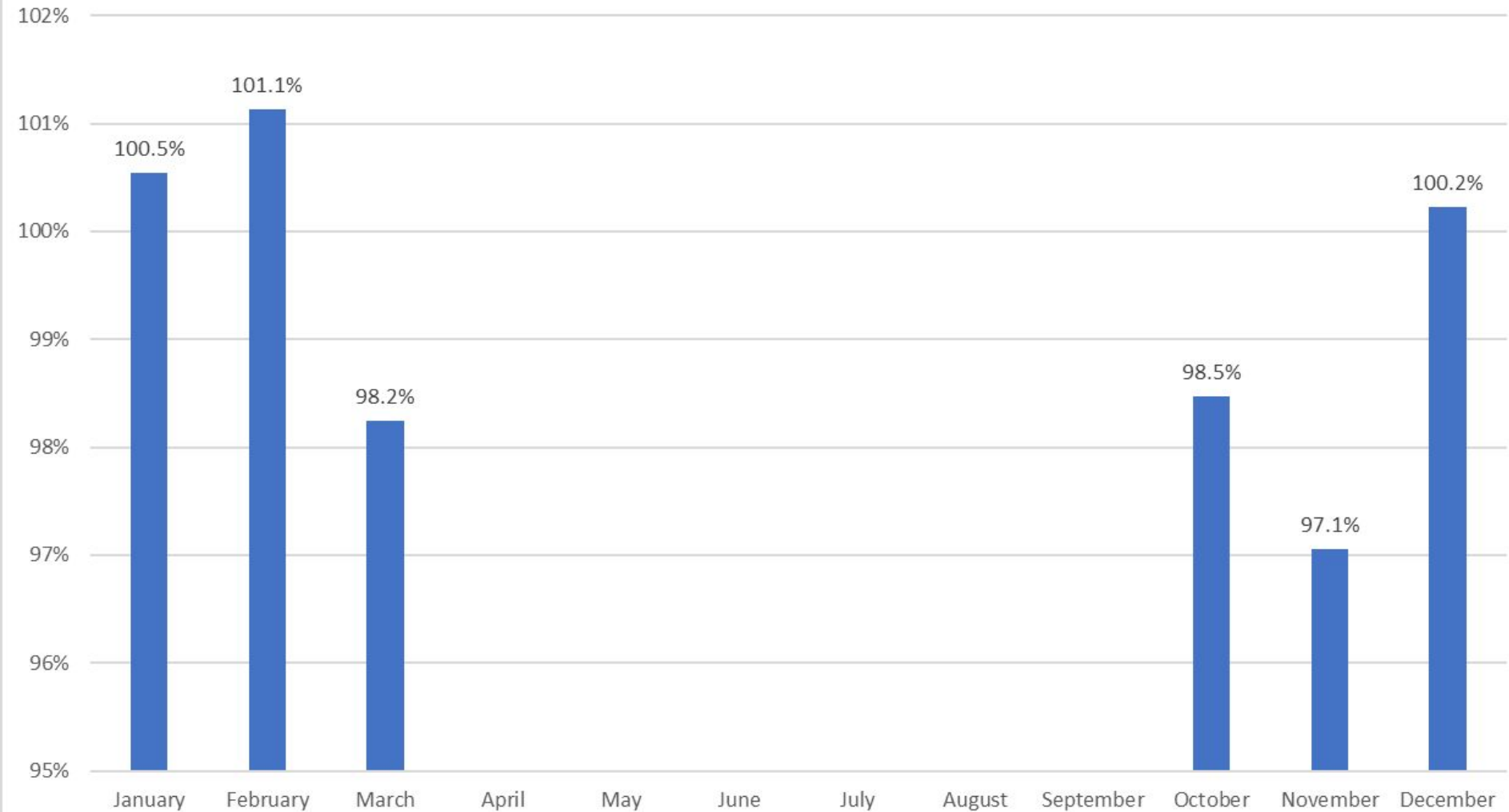
September 2022

Presentation Overview

- **Typical Power Performance Project**
- **What can be missed -**
 - **seasonal variation of performance**
- **Is this happening at my project?**
- **What can I do to fix it?**
- **Wrap up and summary**

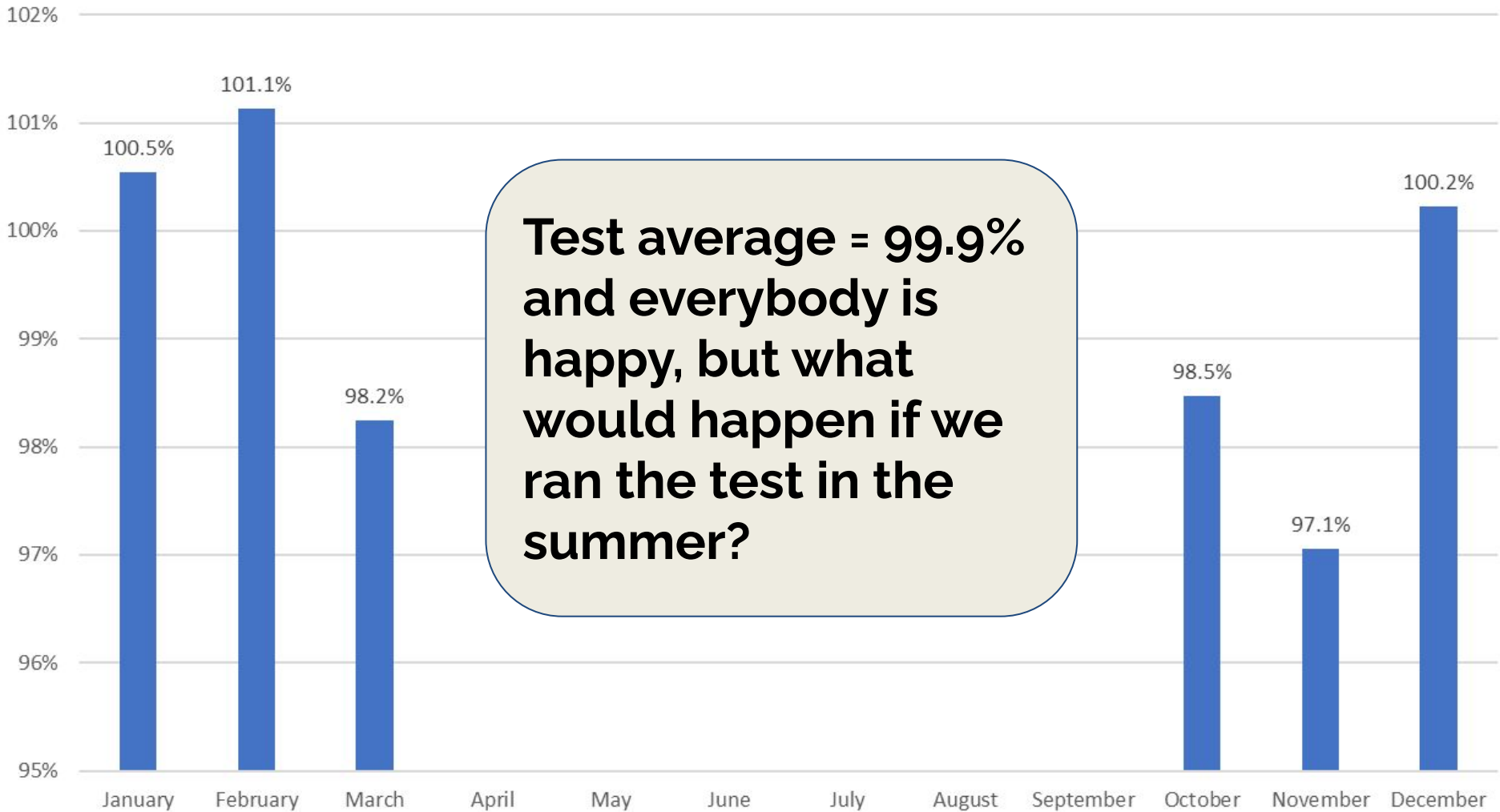
Typical Monthly Variation of Performance

Density Corrected Production/Warranted Production (%) by Month - Site H



Typical Monthly Variation of Performance

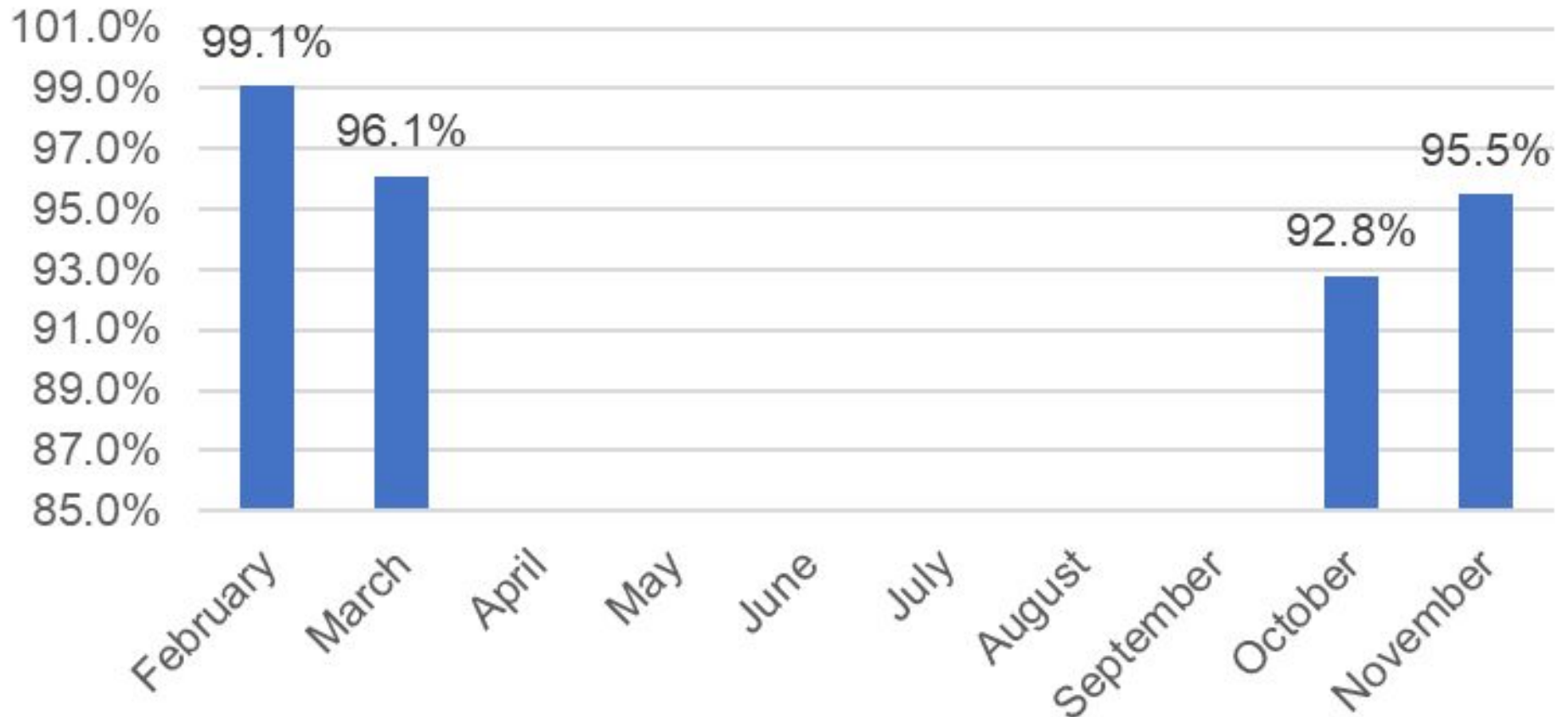
Density Corrected Production/Warranted Production (%) by Month - Site H



Average of three 2.x MW turbines, moderate elevation, 1.12 kg/m³

Site G - winter test

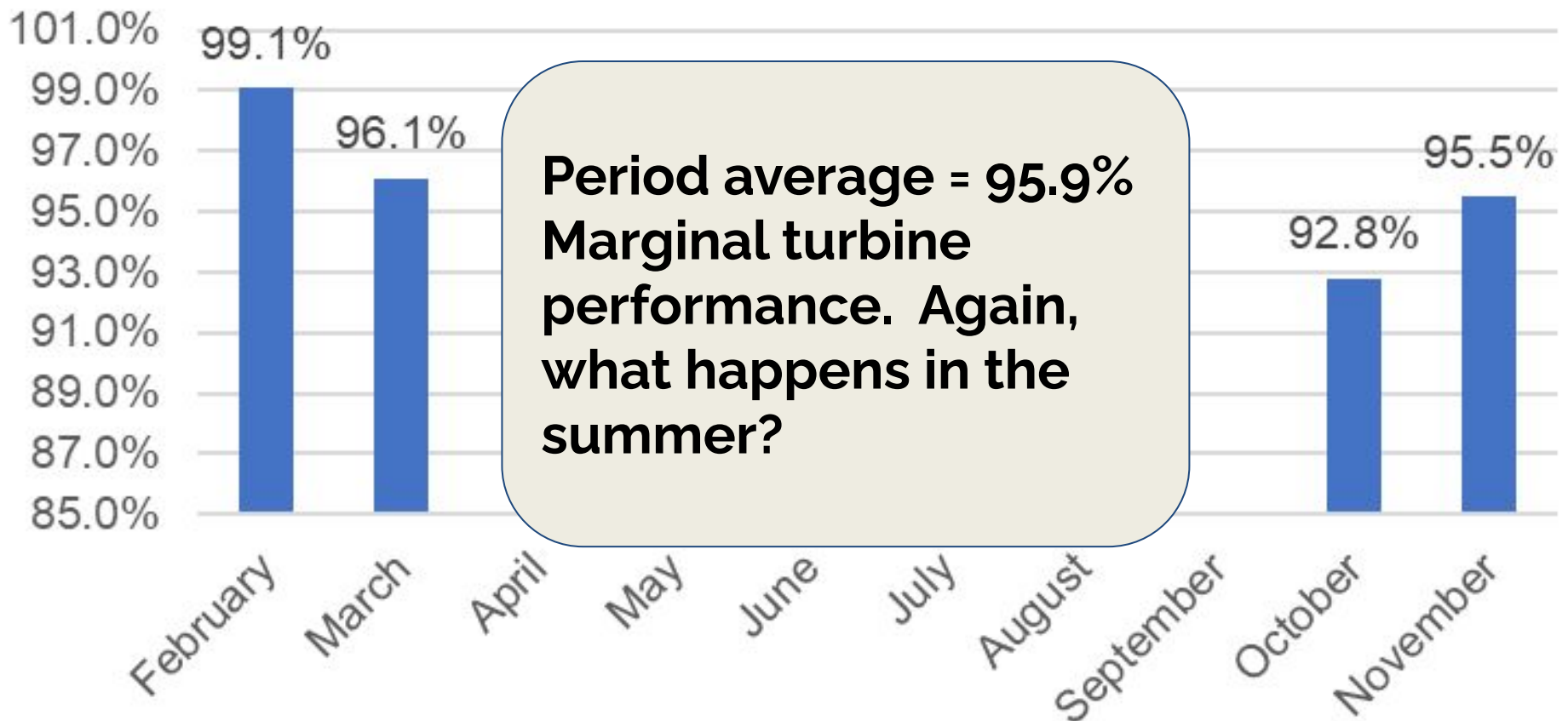
Density Corrected Production/Warranted
Production (%) by Month - Site G



Average of four 2.x MW turbines, moderate elevation, 1.19 kg/m³

Site G - winter test

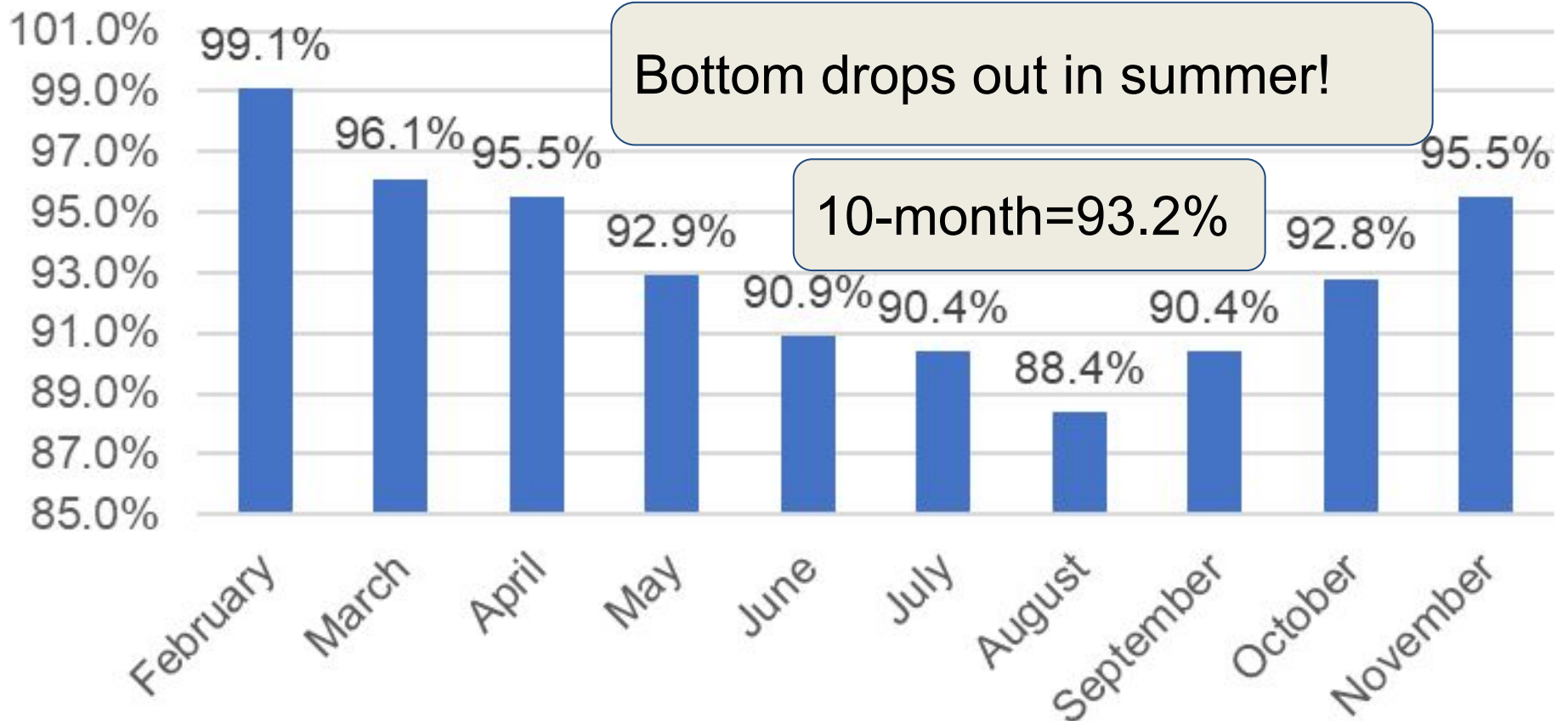
Density Corrected Production/Warranted Production (%) by Month - Site G



Average of four 2.x MW turbines, moderate elevation, 1.19 kg/m³

Site G - 10 month test

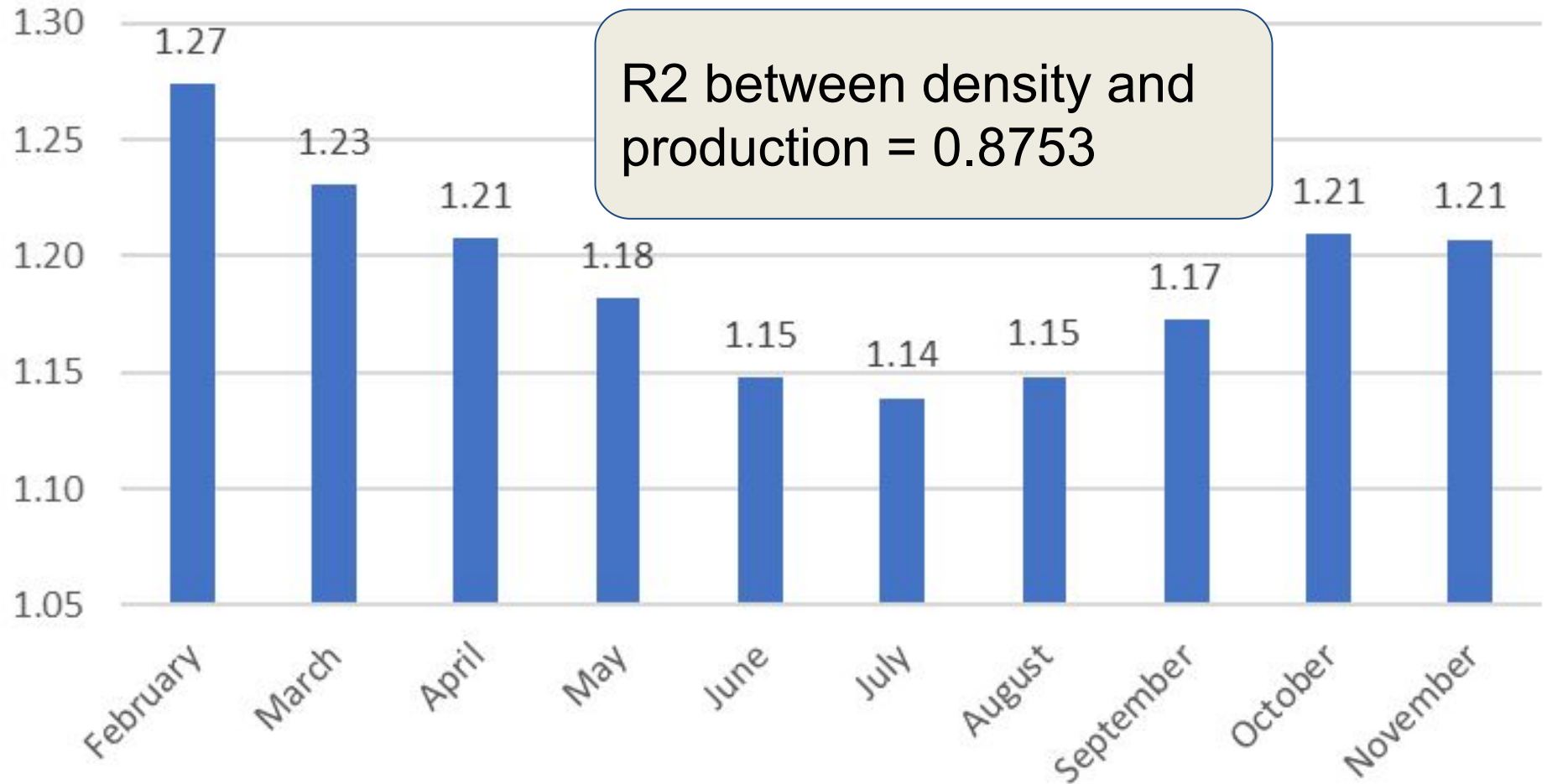
Density Corrected Production/Warranted Production (%) by Month - Site G



Average of four 2.x MW turbines, moderate elevation, 1.19 kg/m³

Site G - 10 month test

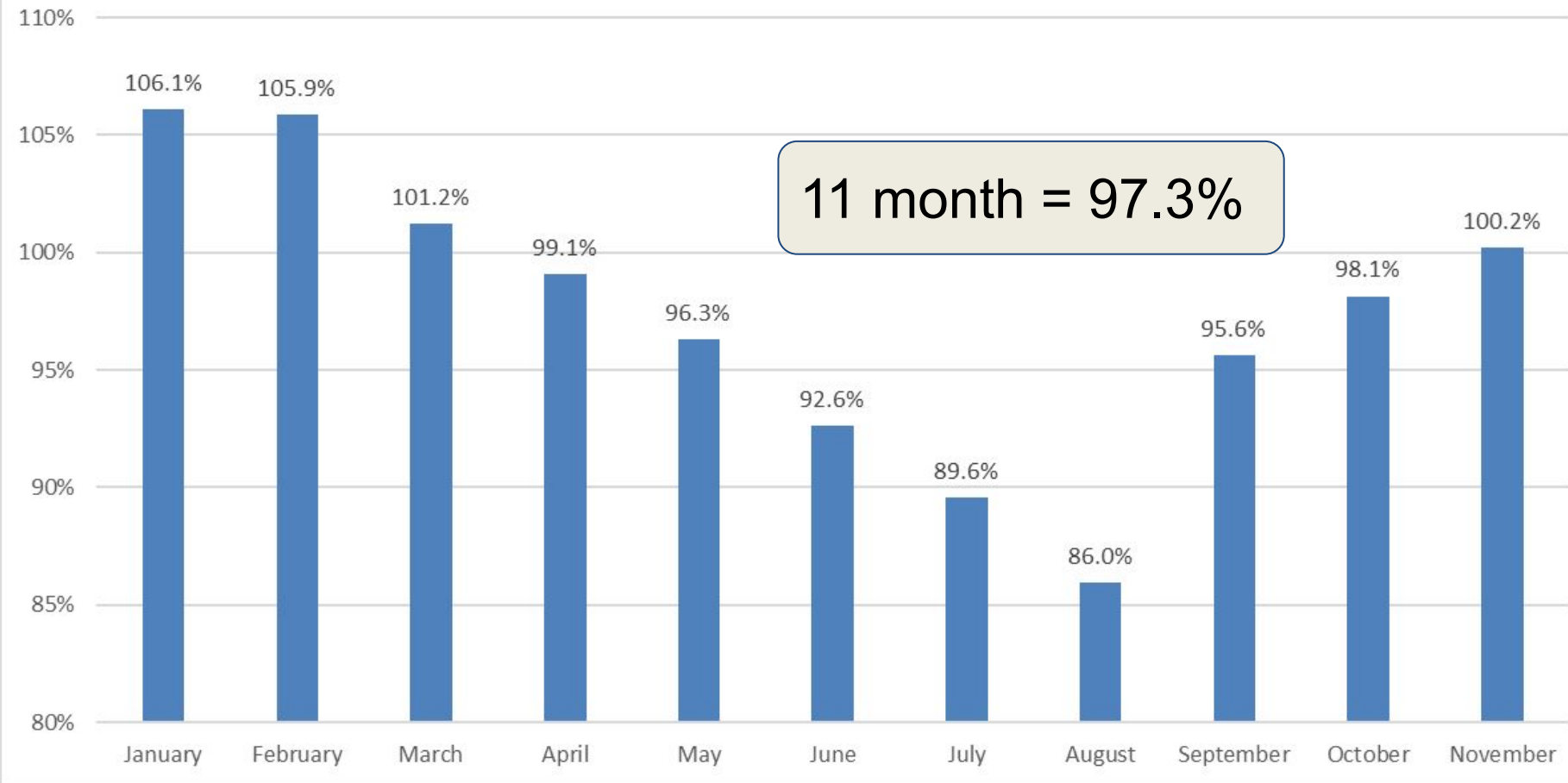
Air Density (kg/m³) - Site G



Average of four 2.x MW turbines, moderate elevation, 1.19 kg/m³

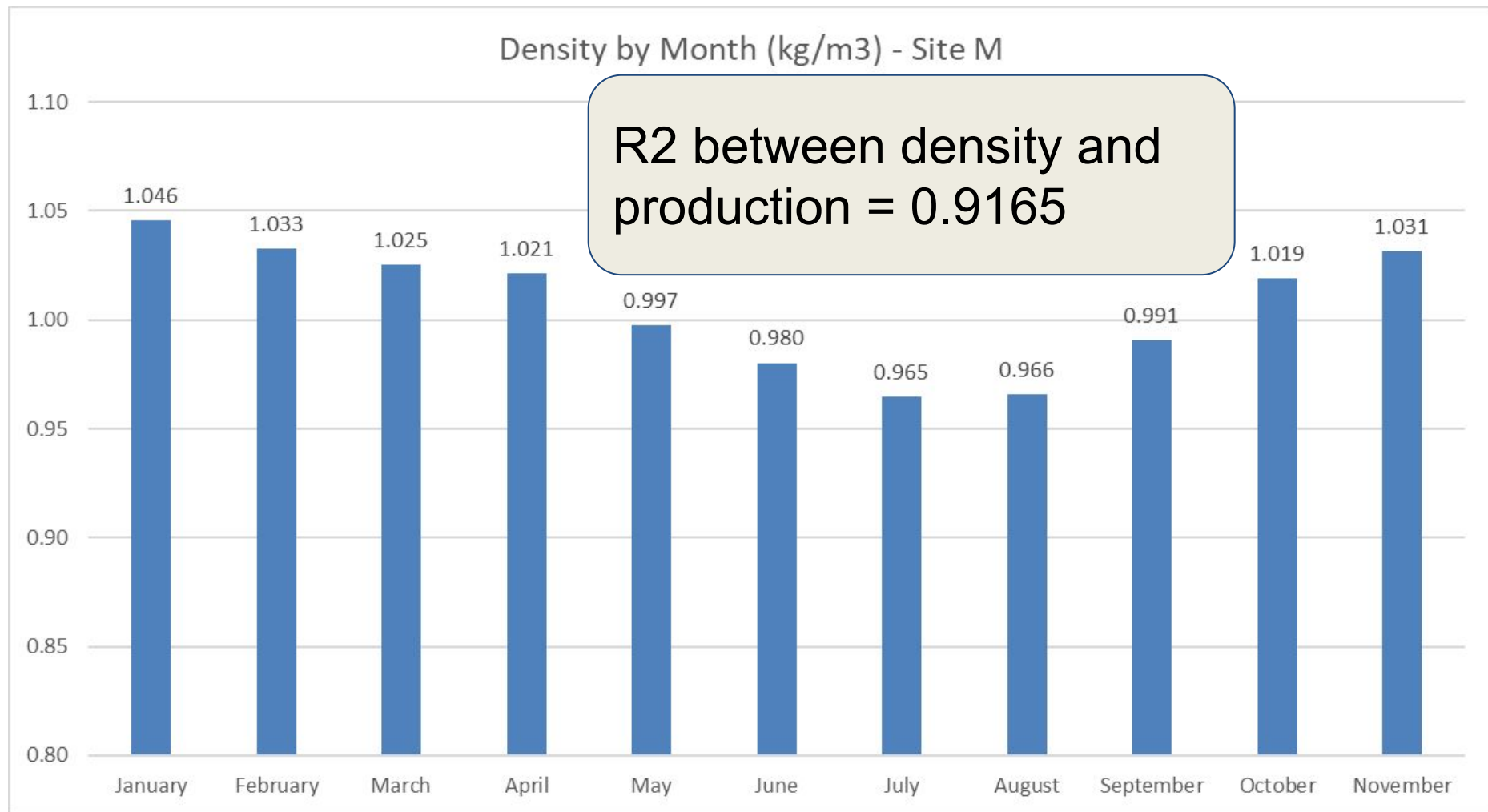
Site M

Density Corrected Production/Warranted Production (%) by Month - Site M



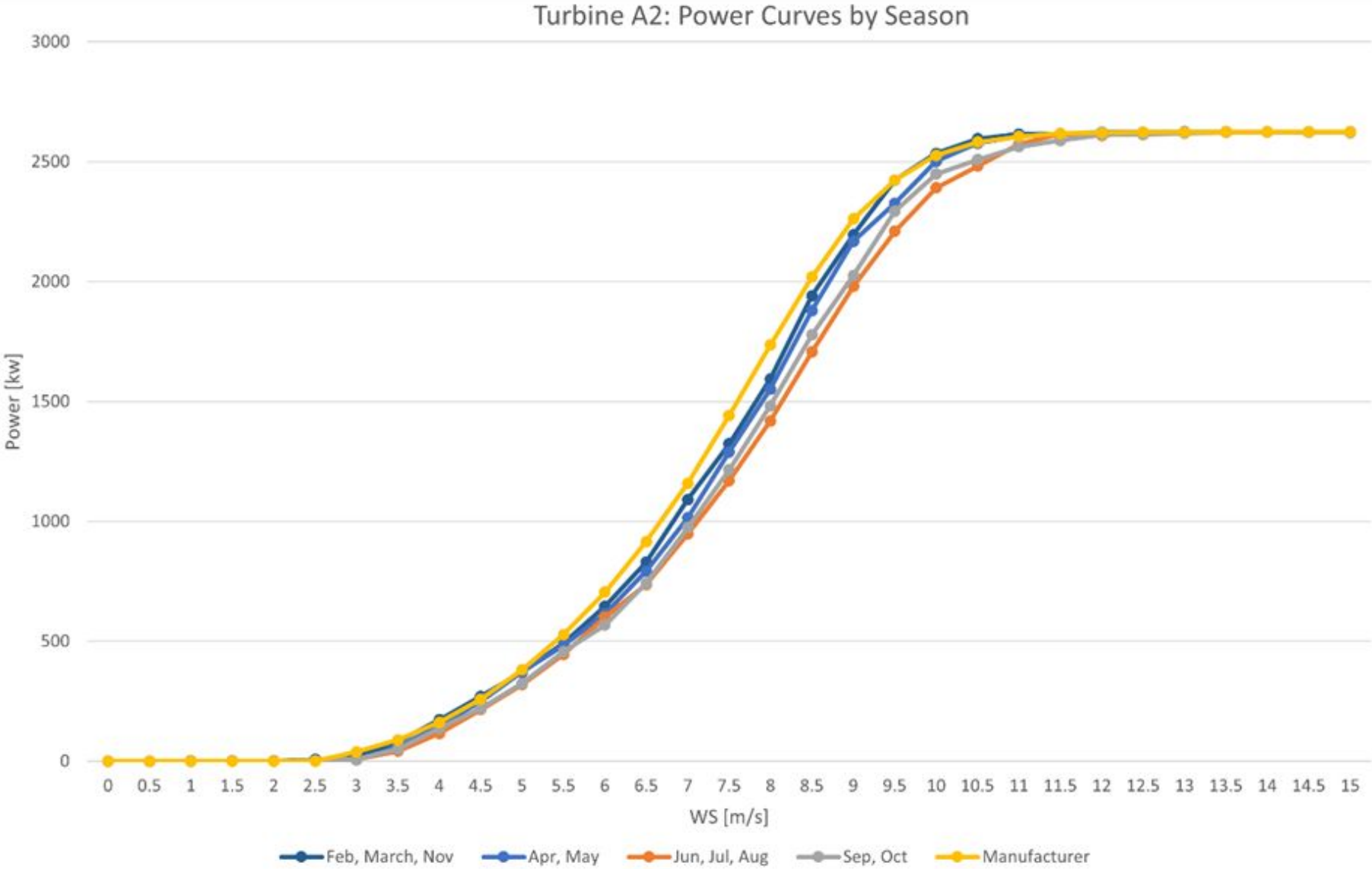
Average of three 2.x MW turbines, high elevation, 1.01 kg/m³

Another example of seasonal variation in performance



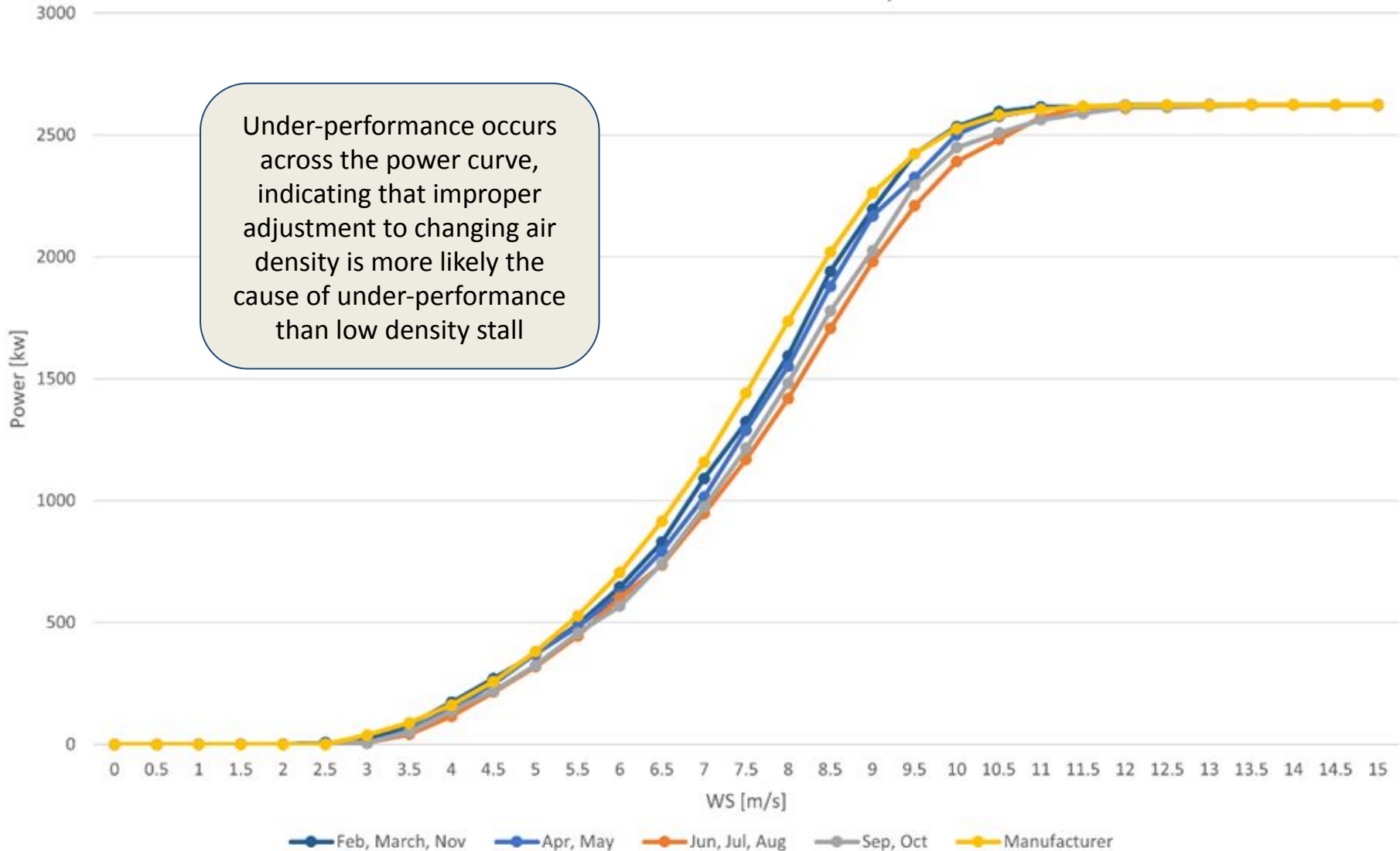
Average of three 2.x MW turbines, high elevation, 1.01 kg/m³

Power Curve by Season - Site G



Power Curve by Season - Site G

Turbine A2: Power Curves by Season

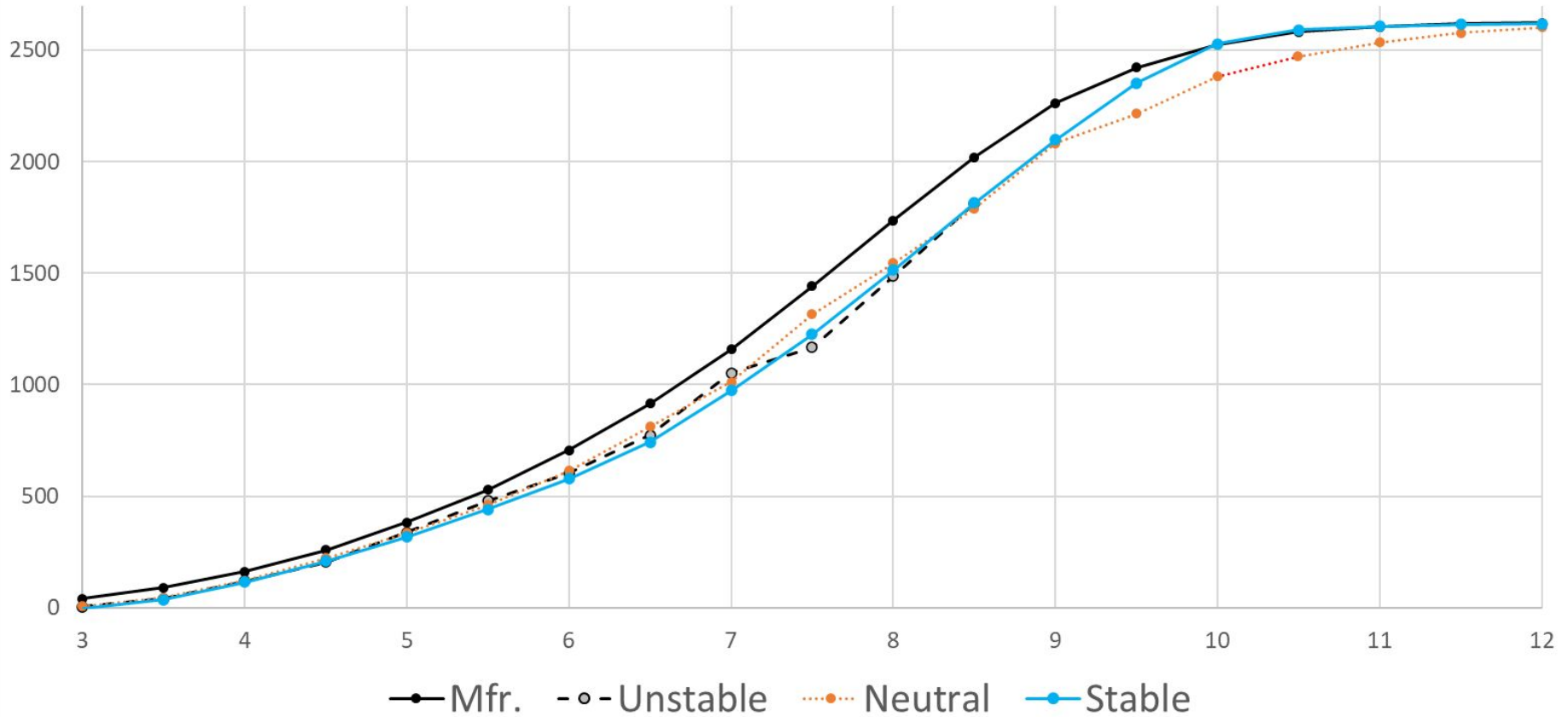


Factors investigated and rejected as causal

- Turbulence Intensity
- Shear
- Inflow angle
- Veer
- Standard Deviation of Wind Direction
- Stability
- Time of Day

Power Curve by Stability Class

(kW vs m/s)



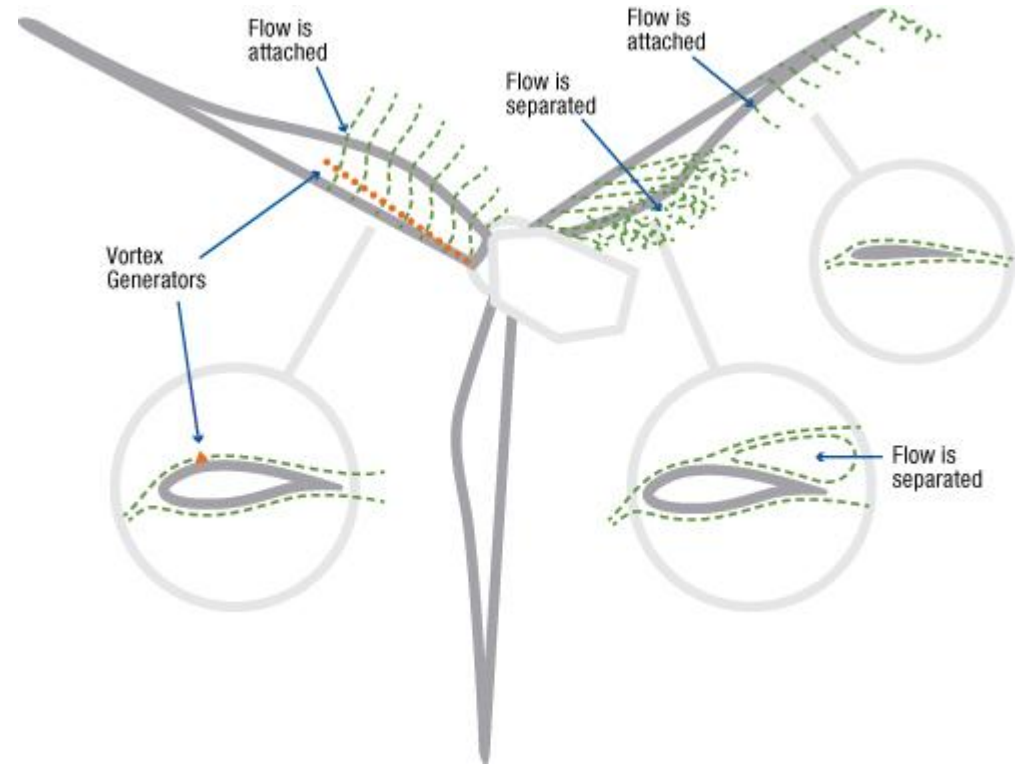
- Performance is not a function of stability

AEP Performance by Pasquill-Gifford Class

Season	Unstable	Neutral	Stable	St Dev
Winter		102%	101%	1%
Spring	89%	94%	94%	3%
Summer	88%	88%	87%	1%
Fall	90%	92%	91%	1%
Annual	90%	92%	91%	1%
St Dev	1%	6%	6%	

What to do when things go wrong - Talk to the OEM!

- Control system adjustment
- Vortex Generators
- Blade cleaning



How can I prevent this from happening at my project?

- **Power Performance Testing across the seasons**
 - **Recommended 6 months of testing including some winter and most importantly - some summer**
- **Testing in winter could mask seasonal under-performance**

Thank you.

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