

Powerful Power Curves: A production-proven, open-source schema for wind turbine power curves

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Abstract

Power curve documents contain highly sensitive data - access to which should be carefully managed for good commercial and technical reasons.

This appears to conflict with the trend toward digitalization, especially seamless data exchange, which enables reduction in:

- time-to-market for new wind turbines,
- time-to-financial-close for new wind farms, and
- workflow friction between internal and external teams.

These seemingly opposed considerations can be reconciled (and access control enhanced) by adopting a so-called schema - a public description of the data structure - and (pending appropriate access and permissions) delivering power curve data to other stakeholders which conforms to the schema.

We here introduce a schema for power curve data, discussing downstream applications and tools together with lessons learned over two years of trials.

Objectives

We here introduce an open-source JSONSchema to describe a wind turbine power curve and its associated metadata.

We will show some downstream tools uses and benefits of the approach, including automated reporting, human-based QC, and generation of web forms for data entry.

Finally, the talk will cover opportunities for collaboration and touch on some limitations and areas in which the schema should continue to evolve.

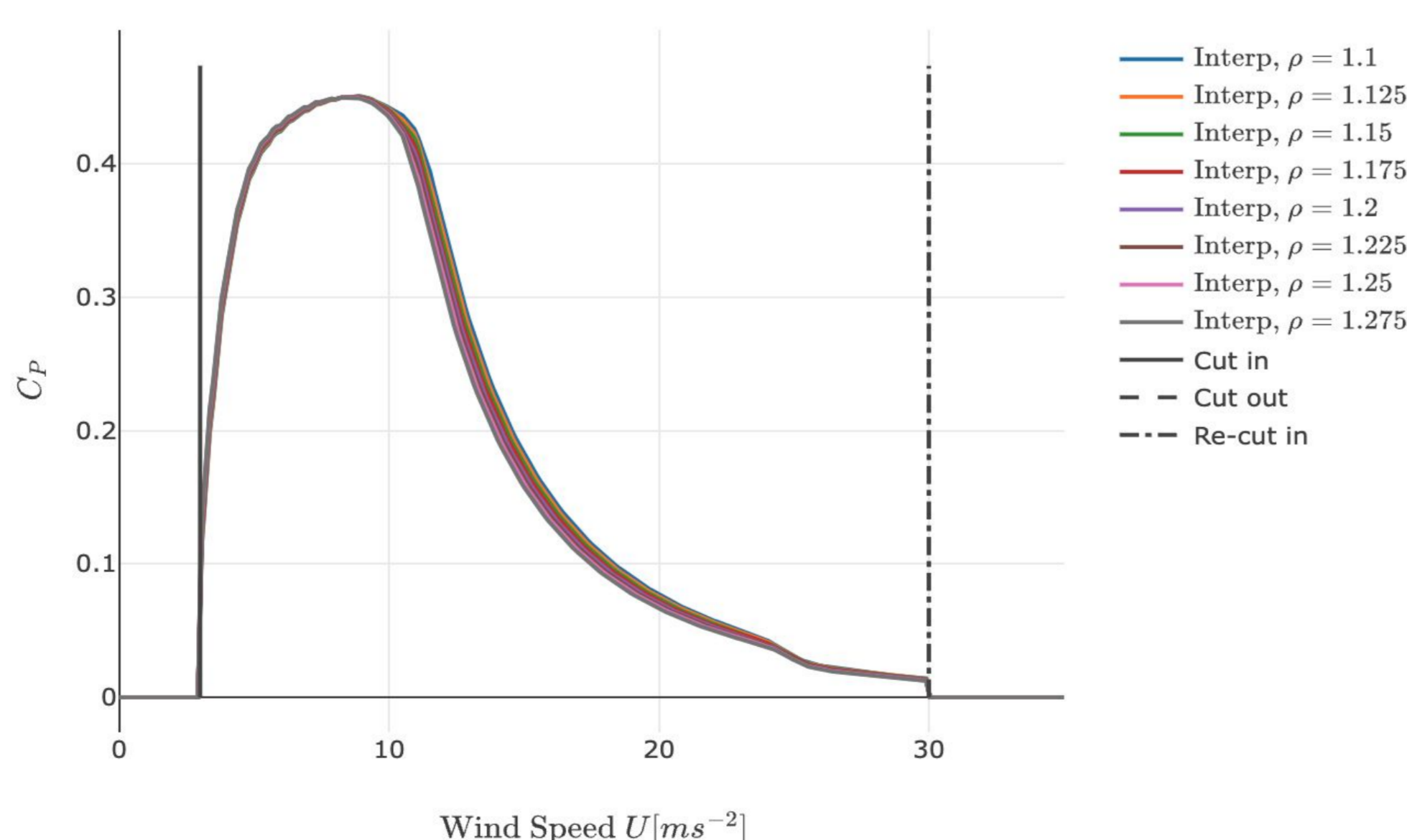
Method

Working with industry partners, we initially gathered 20+ turbine power curve data sheets to which we had been permitted access. In order to automate design processes using them, a consistent data structure was required.

Items in the data sheets were evaluated as being common ("all turbine power curves have this"), uncommon ("some turbine power curves have this") and extraordinary ("rarely seen"). Data was extracted using a mixture of manual and OCR approaches, then iteratively refined toward a common, versatile pattern expressed using the JSONSchema specification.

The array ordering was optimized to default to efficient C-style memory access alignment for typical usage patterns in downstream applications.

Subsequently, data sheets from many more turbines (as required over a period of two years) were extracted into a compliant form, with minor evolutions of the schema to encompass subtleties encountered.



The resulting format enabled quick implementation of automated validation/reporting, plus a managed workflow for manual Quality Control checks, with a browser-based tool interactive value checking during the QC process, all facilitated by having a common schema.

Results

The resulting schema handles complexities including

- multiple operating modes,
- multi-dimensional parameter (eg air density, turbulence, wind speed),
- different ratings and cut in/out criteria on a per-mode basis
- provision of values as absolute or coefficient (P/CP and T/CT)
- and many more.

The schema has been proven versatile and useful for over two years in a production system for array design, where it has been used to describe >30 power curves over 8 major turbine manufacturers.

There are some known limitations (particularly re. certification metadata) and more may emerge - evolution will continue and collaboration is very welcome.

See the schema here >>>



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Benefits and downstream tools

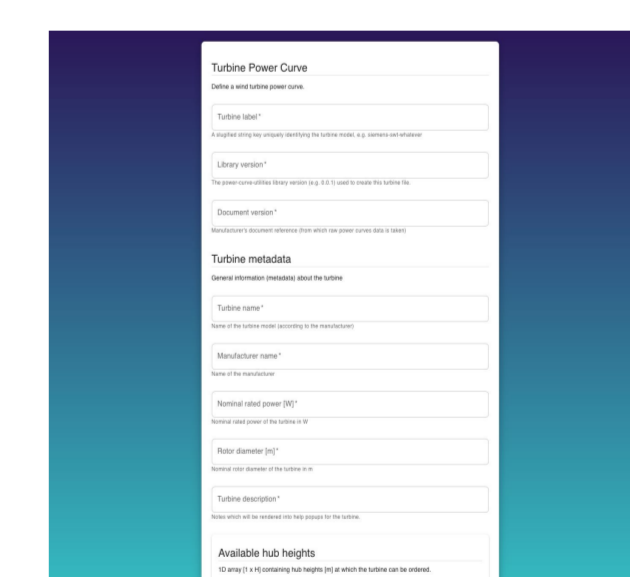
In a scientific/engineering environment, adopting a JSONSchema allows everybody to get instantly on the same page about what data actually ***IS***.

The practice:

- **Dramatically reduces the 45% of working time that typical engineers/scientists spend preparing data (Anaconda, 2020)**
- **Helps teams cross "the technology chasm" to deliver business outcomes, like accelerated time-to-close, by allowing the ecosystem of downstream automations and tools to develop (Gartner, 2019)**
- **Fosters greater control and auditability of data exchange/access (through strict permitting workflows combined with automation) than manually emailing sensitive PDF documents to stakeholders**

As an example of a useful downstream tool, web forms can be autogenerated for data entry, as can interactive charts for data QC and exploration.

See a webform generated from the schema here >>>



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With many thanks...

This work was entirely sponsored - and the resulting Schema open-sourced for the benefit of the industry - by Wind Pioneers Ltd.



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