Vestas

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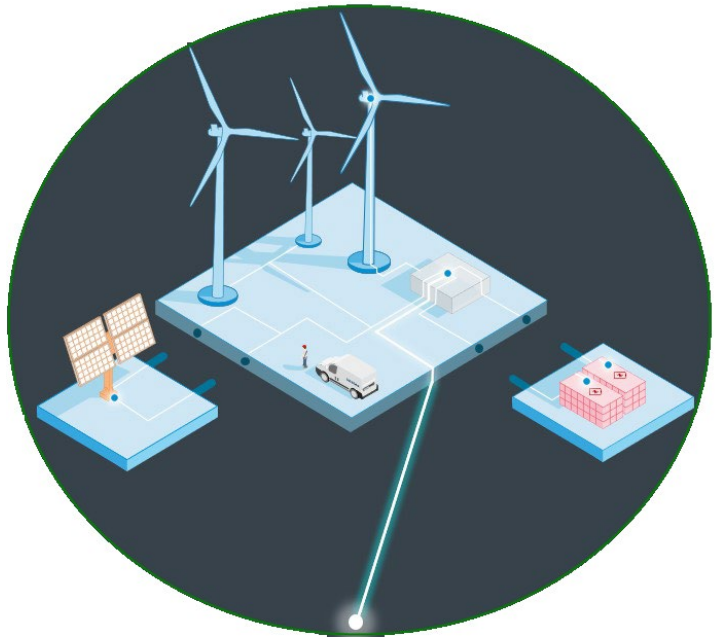
Reliable validation and commissioning of hybrid power plants

Power System Integration Module, Vestas Wind Systems A/S, Aarhus, Denmark

Per Lund, Kouroush Nayebi, Mogens Feldthaus Fyhn,
Bo Yin, Miguel Angel Cova Acosta, Mads Rajczyk Skjelmose

Introduction



Focus on Hybrid Power Plants consisting of

- Wind Turbines (WTGs)
- Photo Voltaic Panels (PV)
- Battery Energy Storage Systems (BESS)

The Four main initiatives:

1) Development of Vestas hybrid PPC features and best practice commissioning guidelines

2) Qualification of third-party dynamic components

3) Design of Electrical Simulation models of Vestas WTG & PPC to meet market requirements

4) Conduct grid integration studies to demonstrate grid code compliance and ensure hybrid power plant commissioning

Plant Control Functionalities & Supplier qualification

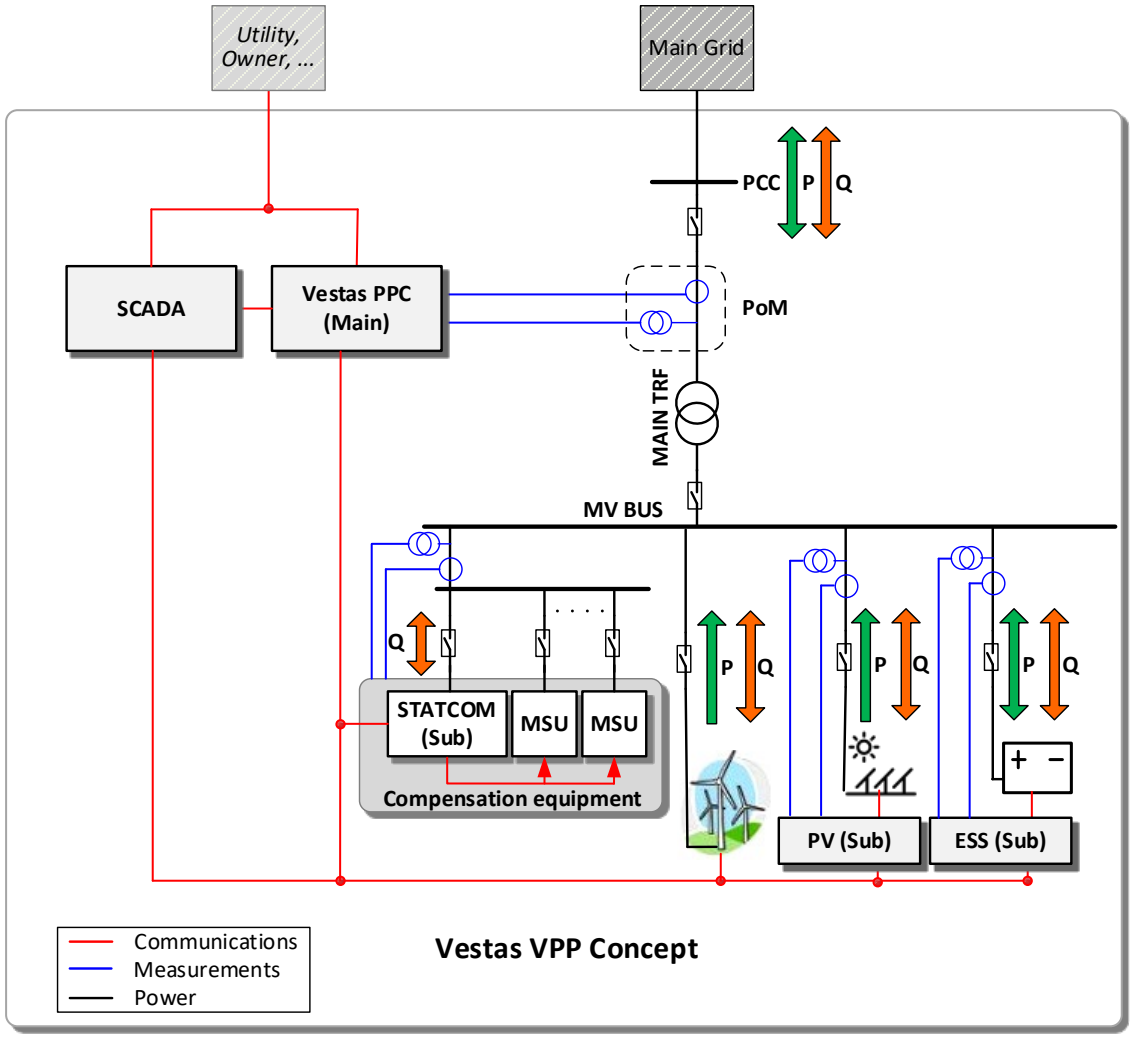
Vestas PPC as main controller

Hybrid Power Plant configuration example

- Vestas PPC configured as Main
  - VT and CT sensing the total production
  - Can offer all the control modes

- Vestas qualified Vendor specific PV & BESS plant controllers
  - Configured as Sub controller
  - Reactive power control
  - Active power control
  - Reporting actual P and Q capability to PPC

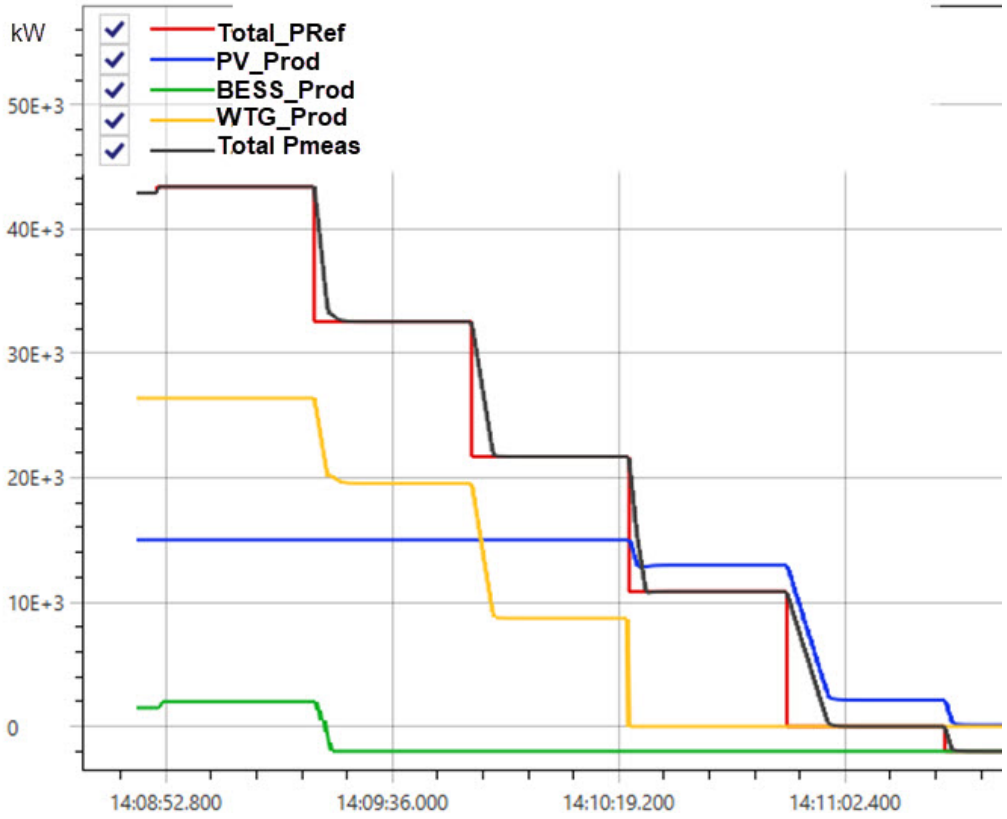
- Vestas qualified Vendor specific STATCOM controllers
  - Configured as Sub controller
  - Reactive power control
  - Reporting actual Q capability including MSU to PPC



PV: PhotoVoltaic
(B)ESS: (Battery) Energy Storage System
MSU: Mechanically Switched Unit

Active and Reactive Power dispatching

Prioritized list – define the order of Assets to generate



Other Options:
Distributed Percentage Part (DPP)

Active power dispatch treats BESS as a storage

- BESS discharging can be used to cover any active power missing from e.g. WTG and PV,
- Any excess power from e.g. WTG and PV will be used to charge the BESS.

Qualification of third party vendor dynamic components

Same process for each dynamic component

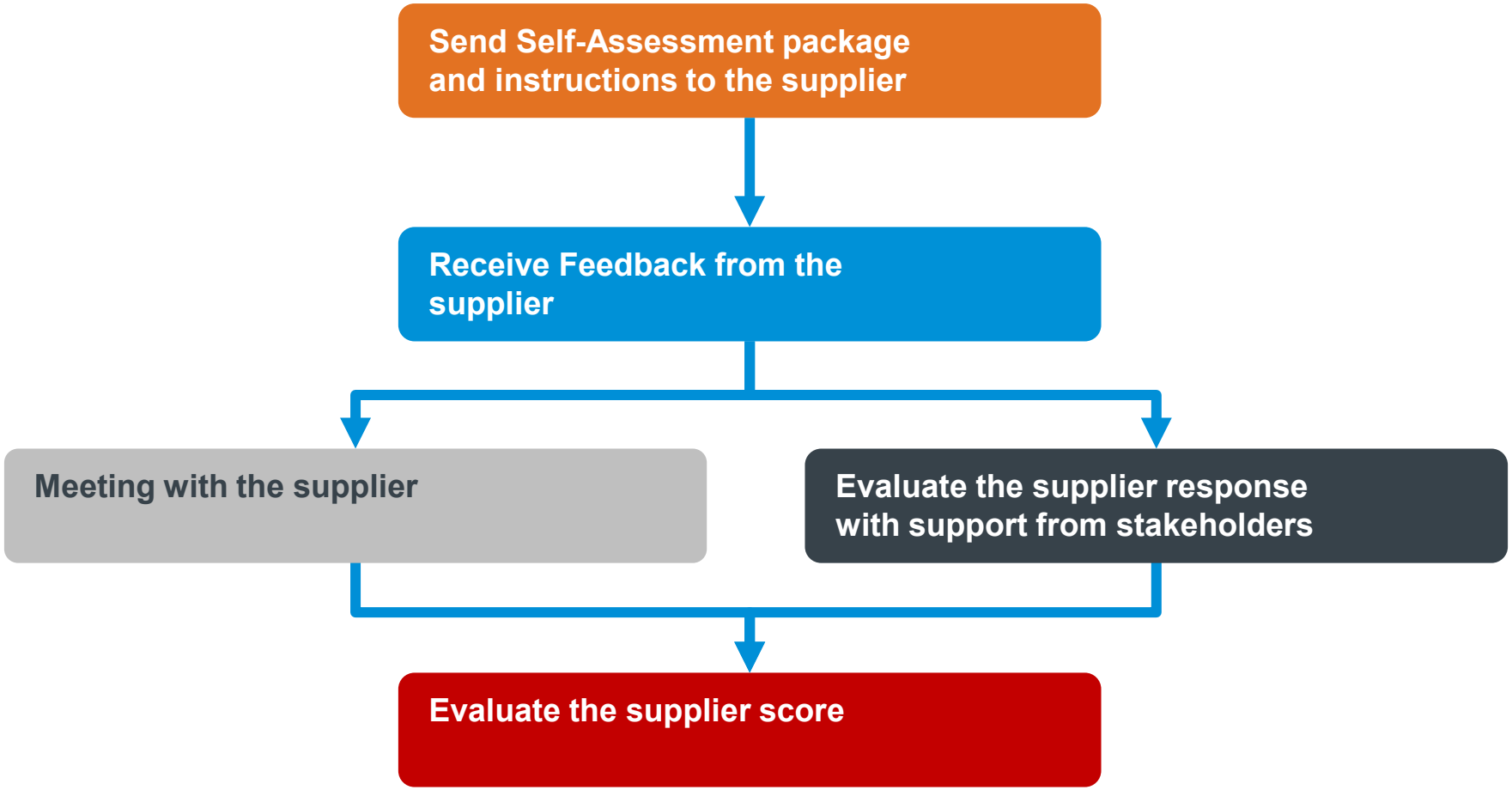
Vestas Preparation:

Component Technical Purchase Specification (TPS) with requirements created incl. D-FMEA and test procedures

Qualification steps:

1. Supplier Self-Evaluation
2. PPC Interface & Performance Test
3. Model Qualification

Process of supplier Self-Assessment



Interface and performance qualification

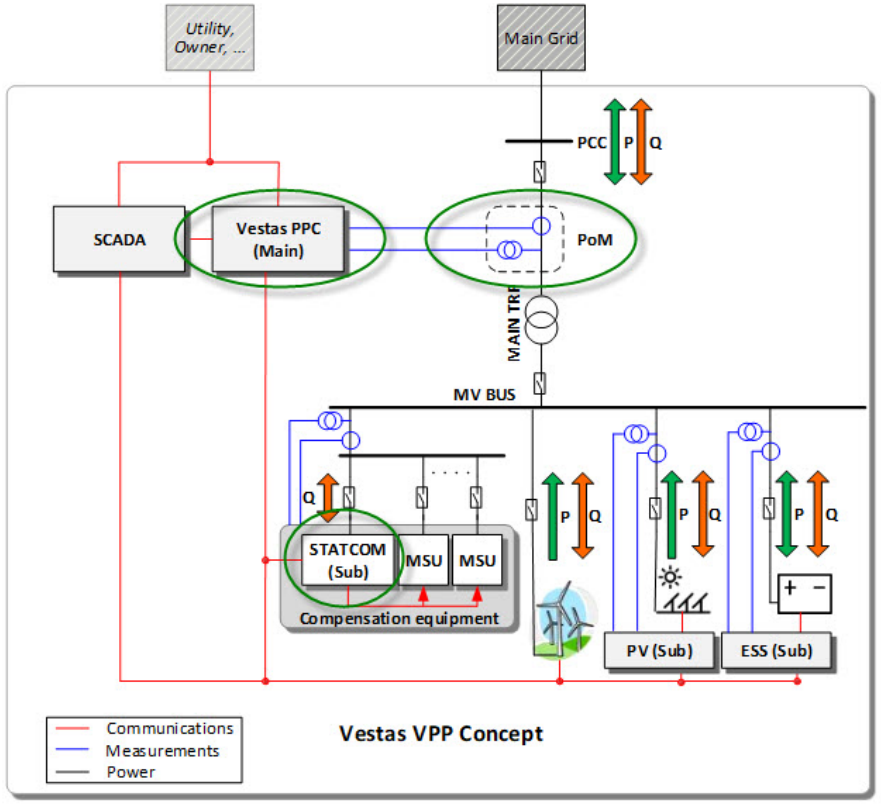
Single supplier qualification sequence – same process for each component

Vestas Preparation:

Test procedure and alignment

Component Qualification tests:

1. Interface test
2. Performance test* (Site/Supplier Lab)



Performance Test

*Performance test depends on the vendor having a test lab/site where a full closed loop test with a real grid connected test system can be conducted.

Model Qualification & Grid Code Compliance

3rd Party Model Integration

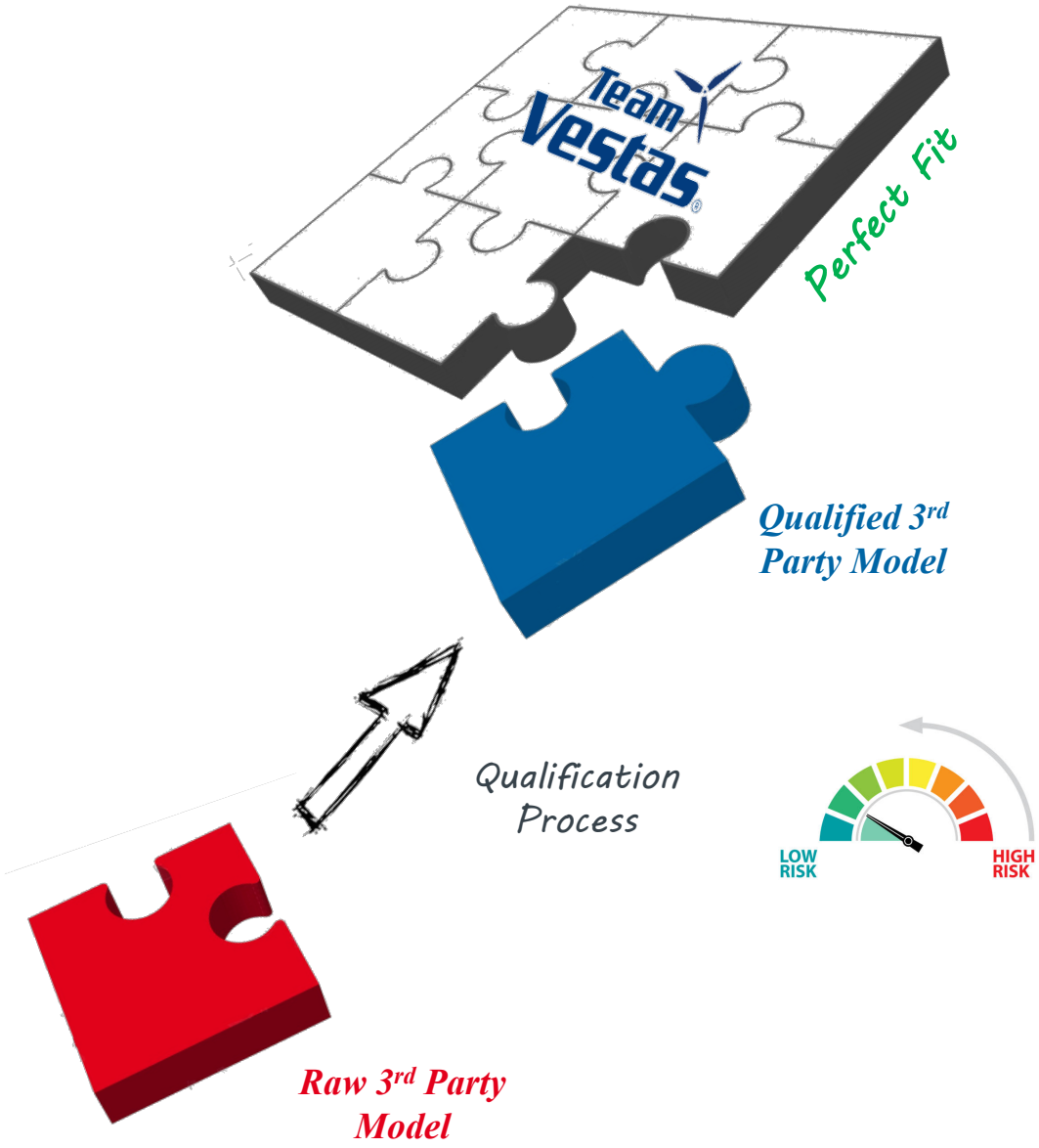
Overview

Objective: Ensure smooth integration of 3rd party OEM electrical simulation models into *Vestas Modelling Framework*

Process*:* Iterative process with OEM to close the gap and reshape 3rd party electrical simulation models, to adapt them to *Vestas Modelling Framework*

Models considered in the process:

- Wind Turbines (WTGs)
- Photo Voltaic Panels (PV)
- Battery Energy Storage Systems (BESS)



Current Market Challenges

Grid Code Compliance Studies

Wind Turbine/PV/BESS:

- Accessibility to parameters in order tune wind turbine performance
- Documentation regarding functionality and description of product functionalities
- Access to internal control variable signals of product
- Access to internal Electrical variables of product

PPC – Plant Controller:

- Accessibility to parameters in order tune PPC performance
- Documentation regarding functionality and description of PPC functionalities
- Access to internal control variable signals of PPC

Issues:

- Time to market
- Confidentiality
- No Process available– Accountability/sign off

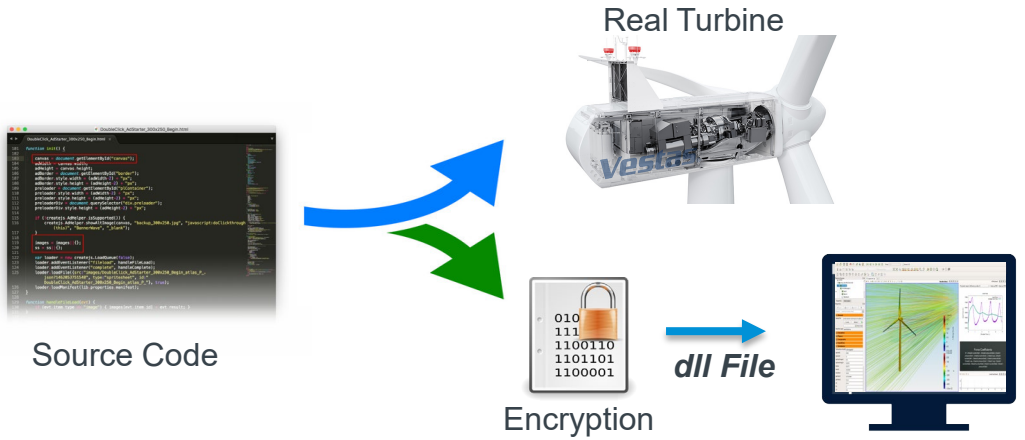
Risks:

- IPR Exposure
- Patent Infringement
- Project delays

UMF Models

Source Code Generated Models

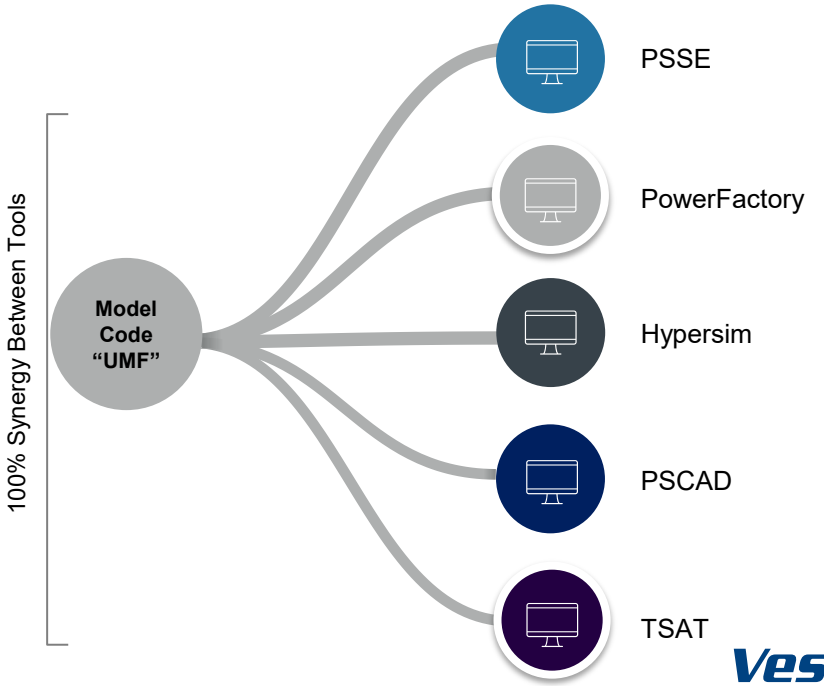
UMF models in EMT and RMS (Electromagnetic Transients) software's are built based on real *source code*.



UMF Electrical simulation models are sensitive and subject to strict confidentiality requirements in relation to among others:

- **Sharing of the models with third parties**
- **Confidentiality term**

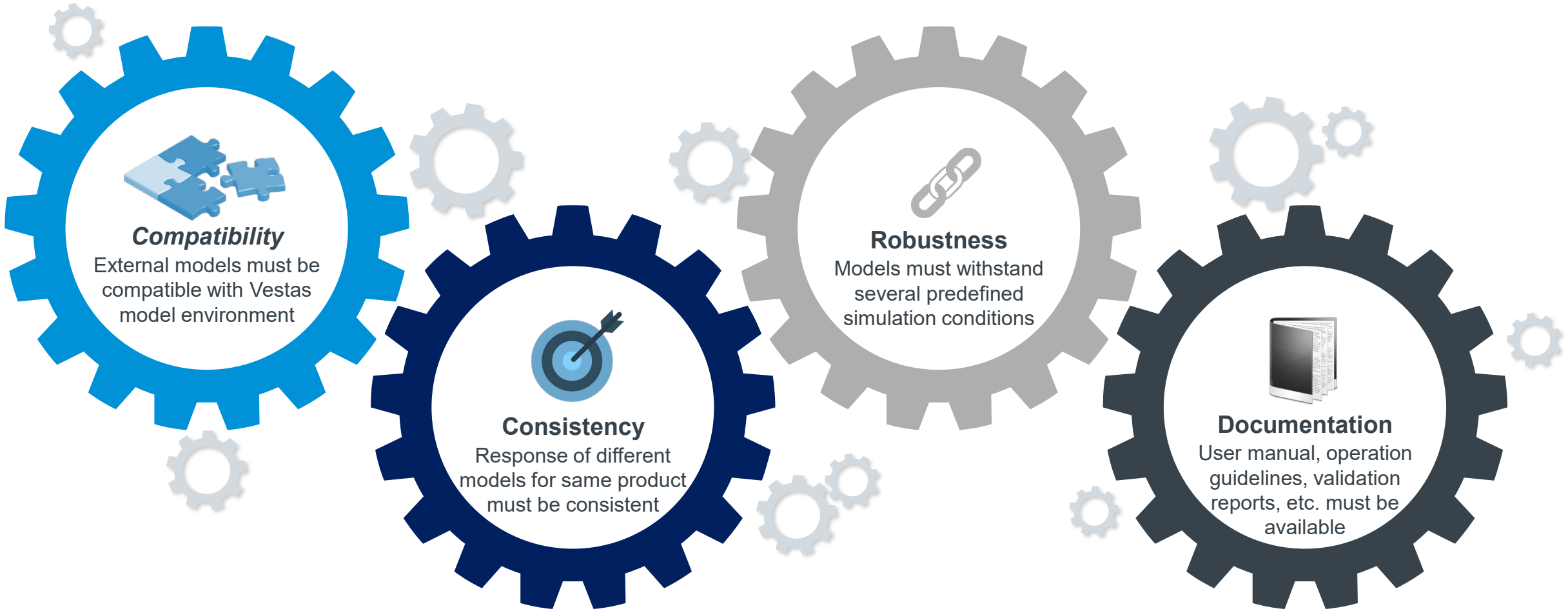
Vestas Wind Turbine Generators (WTG) and Power Plant Controller (PPC) models are able to **Reproduce Vestas real product performance under any grid condition.**



UMF Model Performance = Real Product Performance

Model Qualification

3rd Party Component Pre-Assessment

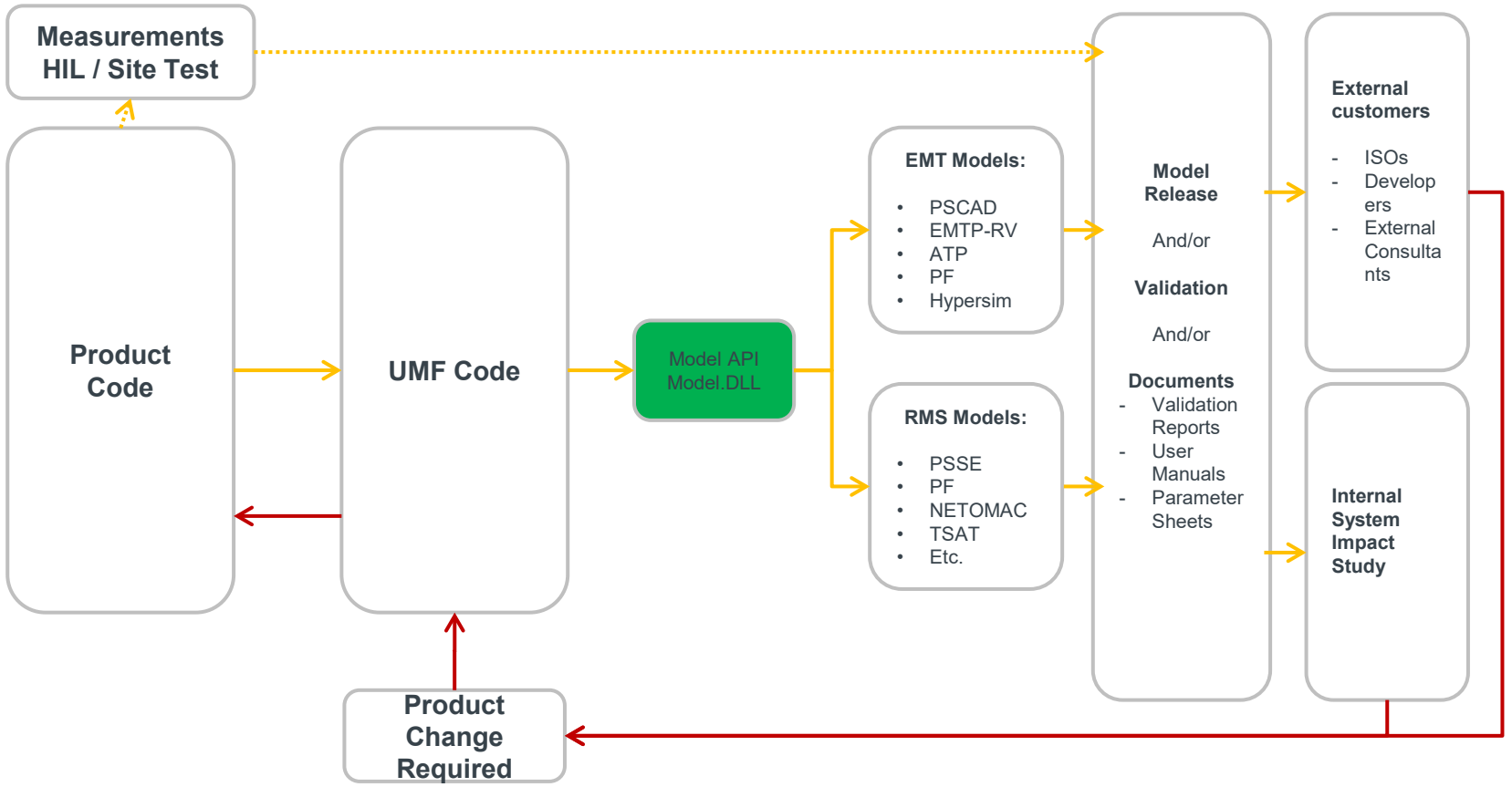


Vestas Model Development

Product to Model to Product - Timeline

Use cases

- Time critical software updates
- Product performance modifications to support grid stability
- Change orders requested by ISO/Developer



Conclusion

- Vestas has a complete set of standardized TPS' for all main dynamic electrical plant components in a hybrid power plant.
- A limited number of OEMs have been already qualified for delivering each of the listed dynamic components.
- Non-compliance risk will be significantly reduced after qualification process is completed
- Optimal balance of plant design, grid code compliance and smooth plant commissioning is achieved trough qualification process.

Even the hardest puzzle have
A SOLUTION