



User-defined vs Generic, Phasor-domain vs EMT

Vestas Wind Systems A/S – Power Plant Solutions

Modelling is More Challenging with GFM

GFM solutions are specialized

- The Industry is currently facing modelling challenges with existing technologies
 - Majority of installed functions in North America are relatively simple
 - Current challenges will be exacerbated when modelling GFM if not addressed
- GFM and other specialized technologies (Mixed OEM sites, weak grid solutions, SSR, detailed AVR/PFR) are being utilized much more frequently
 - These technologies will be OEM and even product specific
 - Detailed, OEM specific modelling will be needed to properly represent behaviours
 - There **NEEDS** to be a mechanism to link the Study and operations “worlds”
- Strong consideration needs to be given to the limitations of Generic Models, Phasor Domain/RMS models, and EMT Models
 - The best tool (when considering grid reliability) will need to be used for each specific study
 - This may mean significant initial effort to gain knowledge in the industry for detailed EMT and Vendor Specific Modelling. Current knowledge and resources **MUST** be increased to sufficient levels in order to meet the more detailed modelling needed in the future
- Since GFM are intended to provide grid-shaping responses, the quality of the grid models will need to be reviewed
 - All models will make a difference, and thus all should be vetted and reviewed

Inaccurate Models = No connection = No sales

Models are required through the entire project life cycle, and they become more demanding as markets mature.



WECC (RMS)

Strengths

Weaknesses

- Easy to Use
- Open and available docs
- Standardized features

- Can't capture OEM nuance
- Can't map to OEM settings easily or at all
- Long development cycle

Uses

- Best used for long term planning or studies with only small-scale grid disturbances
- Only sufficient after **thorough** benchmarking against an OEM model

Vendor Specific (RMS)

Strengths

Weaknesses

- Vestas Model is 1-1 parameter match between model and product
- Ability to have model vs product measurement validation
- Can represent special features

- Learning Curve for end-users
- Potentially more complex than WECC
- Some regions do not accept OEM models

Uses

- Should be used for all studies where reliability is main concern

Vendor Specific (EMT)

Strengths

Weaknesses

Uses

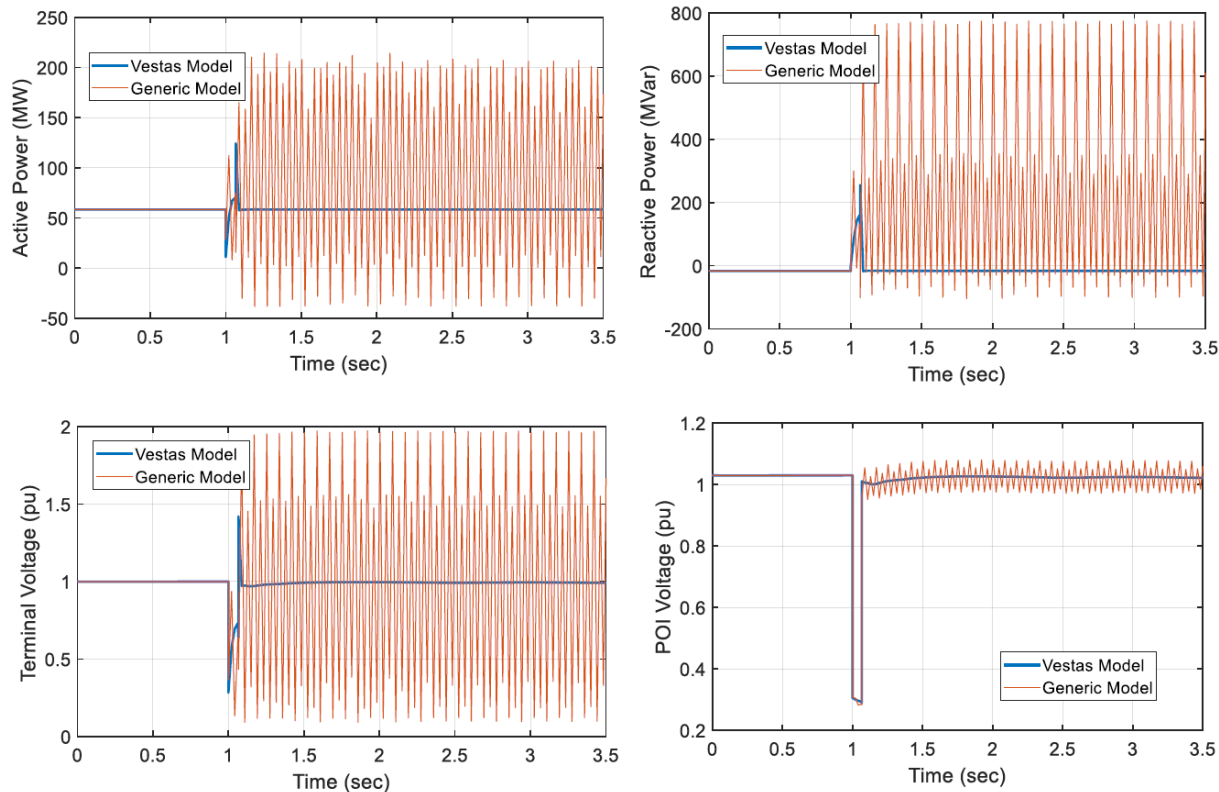
- Extremely detailed
- Appropriate for “difficult” studies (weak grid, SSR, .etc)
- Can include represent mechanical (and other) responses

- Significant computational time
- No widely available grid level EMT model

- Should be used for detailed analysis in plant level studies
- Can also be used to validate RMS models that are not code-based

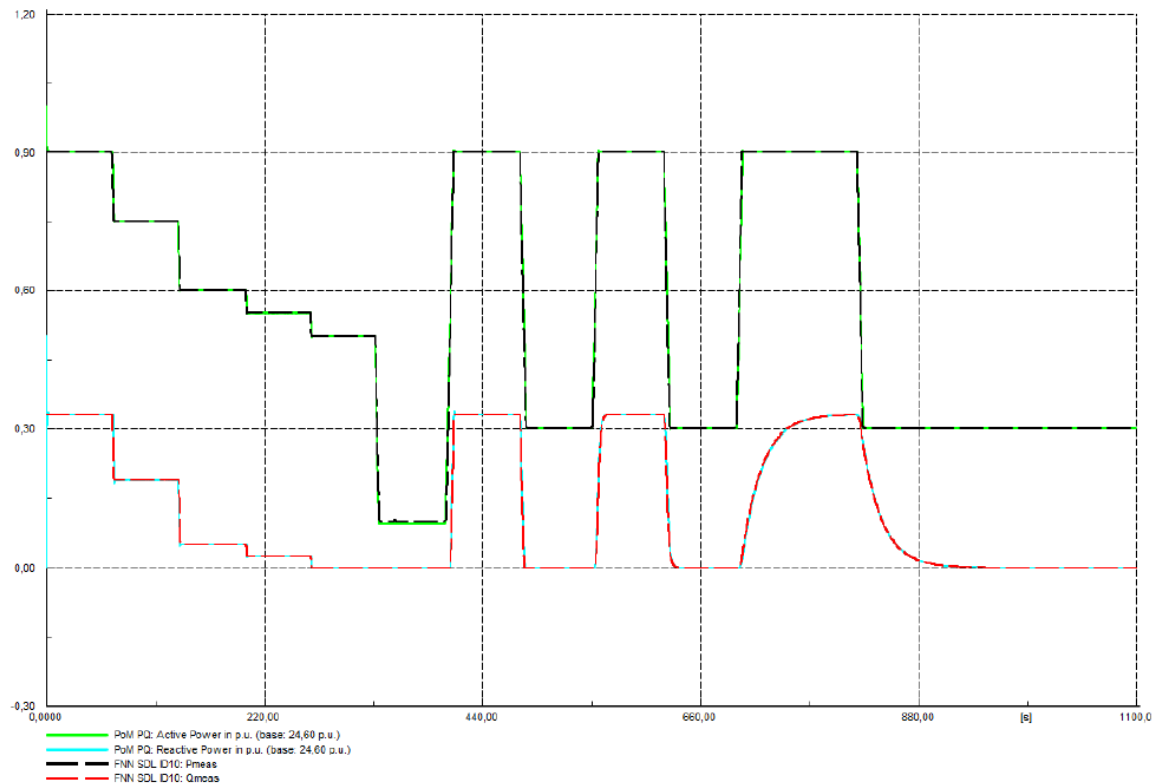
Interconnection Modelling Case Study for US ISO

Generator Interconnection Into Weak Grid Shows WECC Model Instability



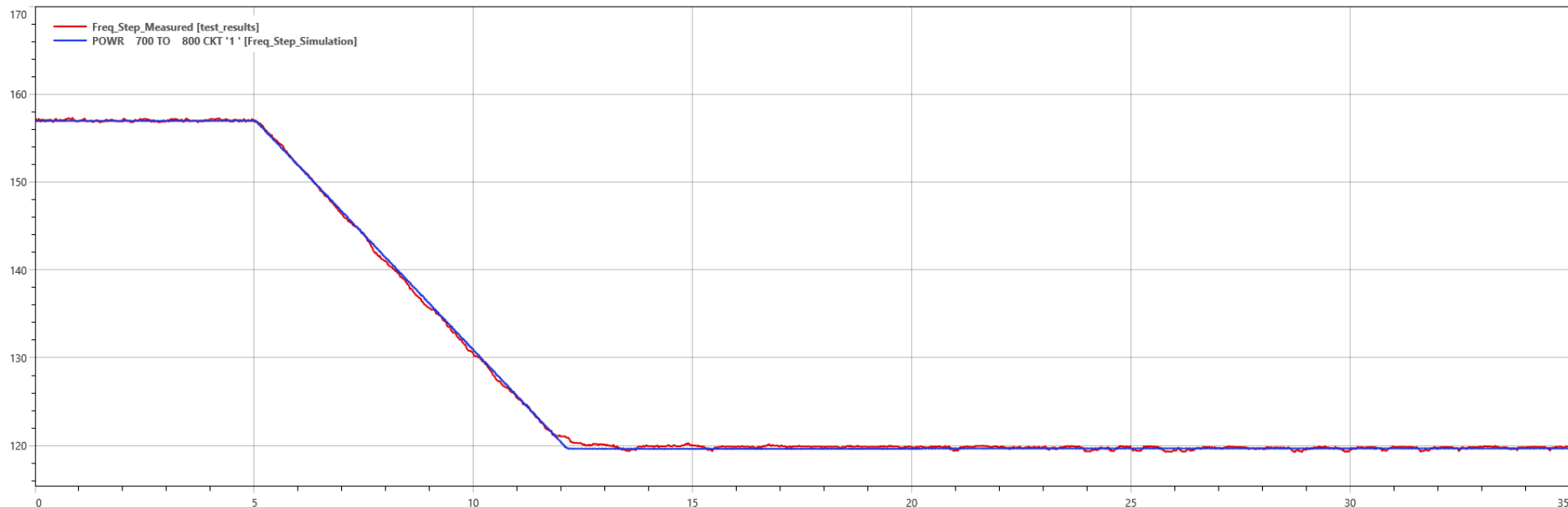
Vestas UDM Results Versus Site Measured Response

Active and Reactive Power Reference Changes Show Good Response Match



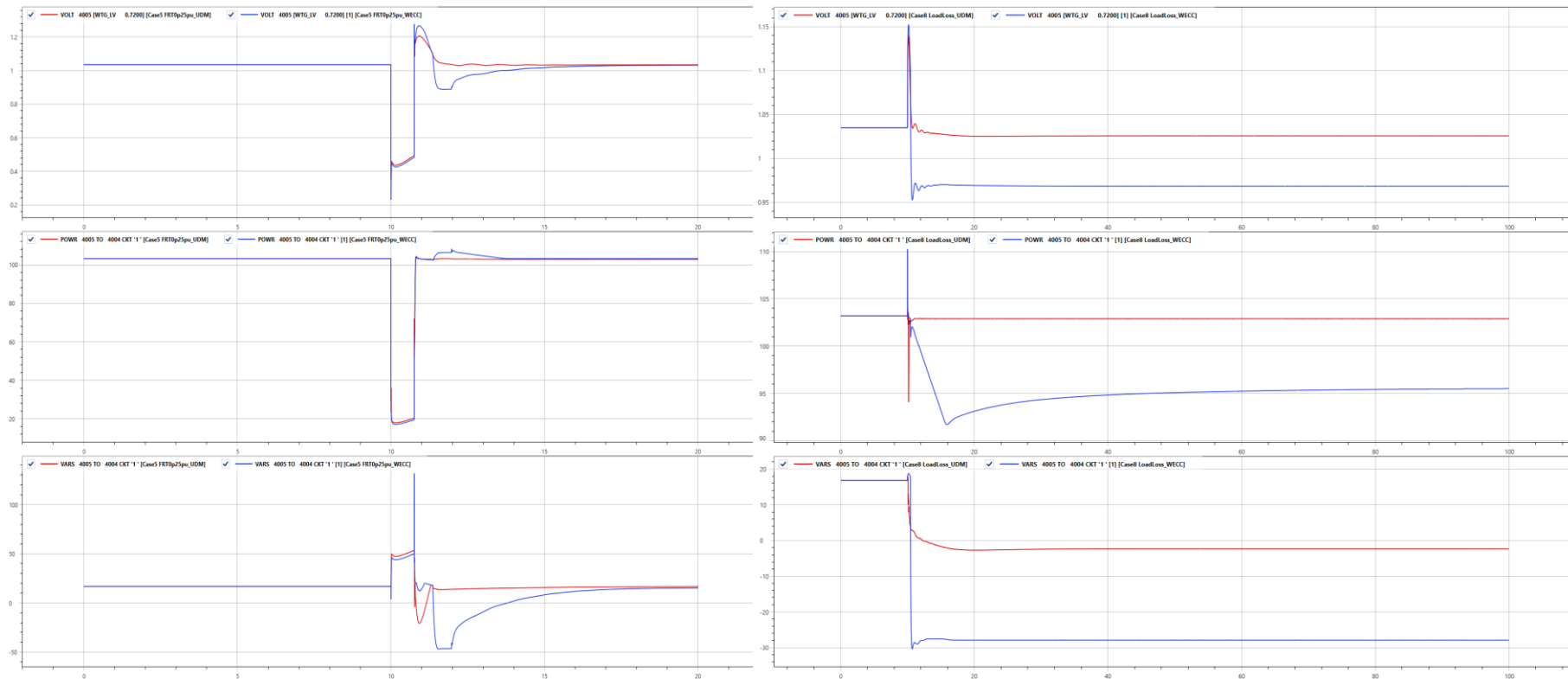
Vestas UDM Results Versus Site Measured Response

Direct parameter download from site software produces results within 1% of MOD-027 test



Vestas UDM Response vs. Vestas Tuned WECC Response

Small Fault and Loss of Load Performed in Small Test System





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Questions

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