

# Real-time Dynamic Modelling of the Irish Power System

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Eirgrid

# Manhattan: morning 14 August 2003

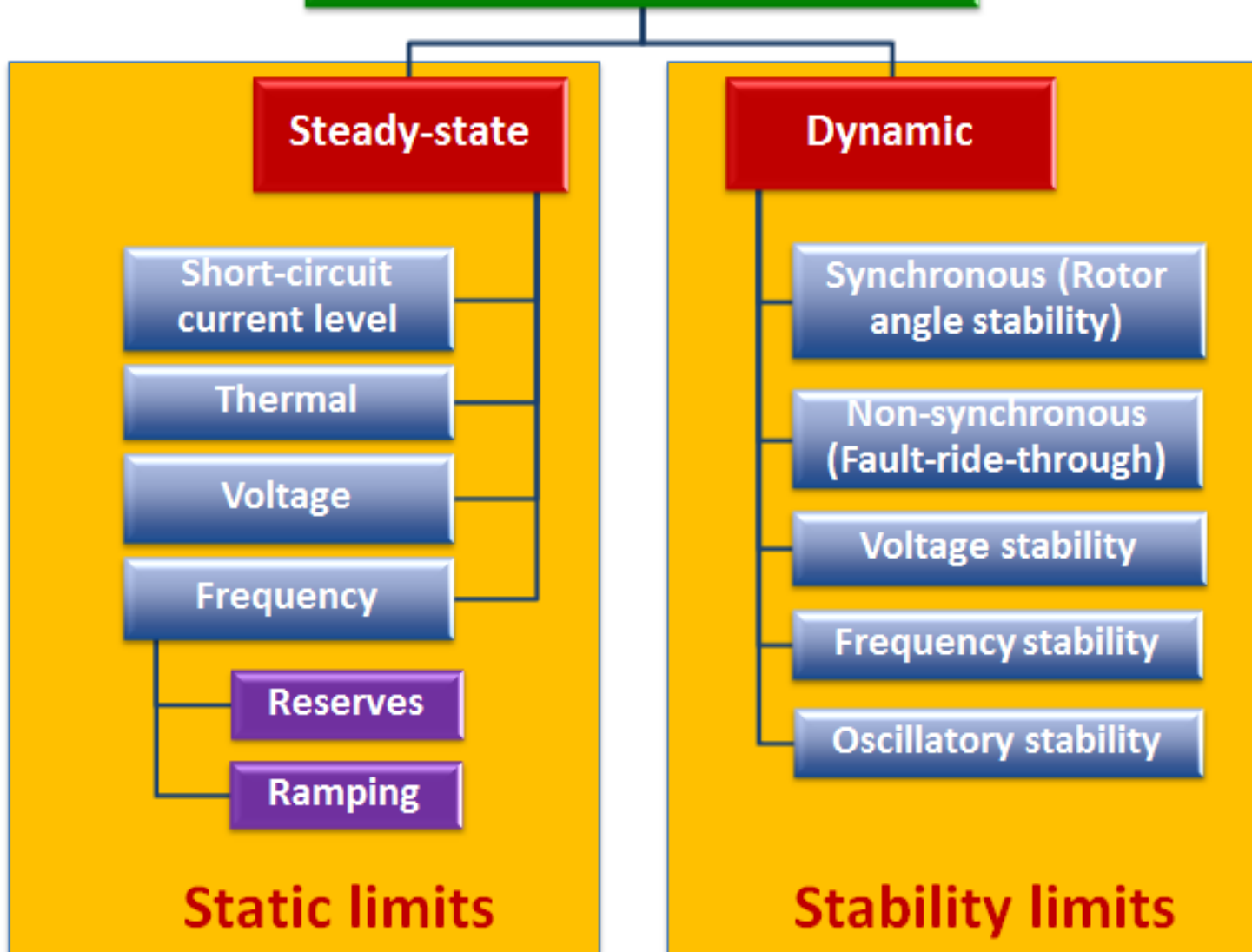


*Photo by Mike Albans/NY Daily News Archive  
via Getty Images*

**EIRGRID**

**SONI**

# Operational Security



# WSAT Development Timeline

**Sep 2008**

MAWAT  
Concept is  
proposed  
  
Develop-  
ment the  
tool as  
WSAT jointly  
with  
Powertech  
Labs  
(Canada)

**May 2009**

WSAT  
installed for  
testing and  
validation

**Sep 2010**

On-line  
WSAT is  
officially  
launched in  
NCC

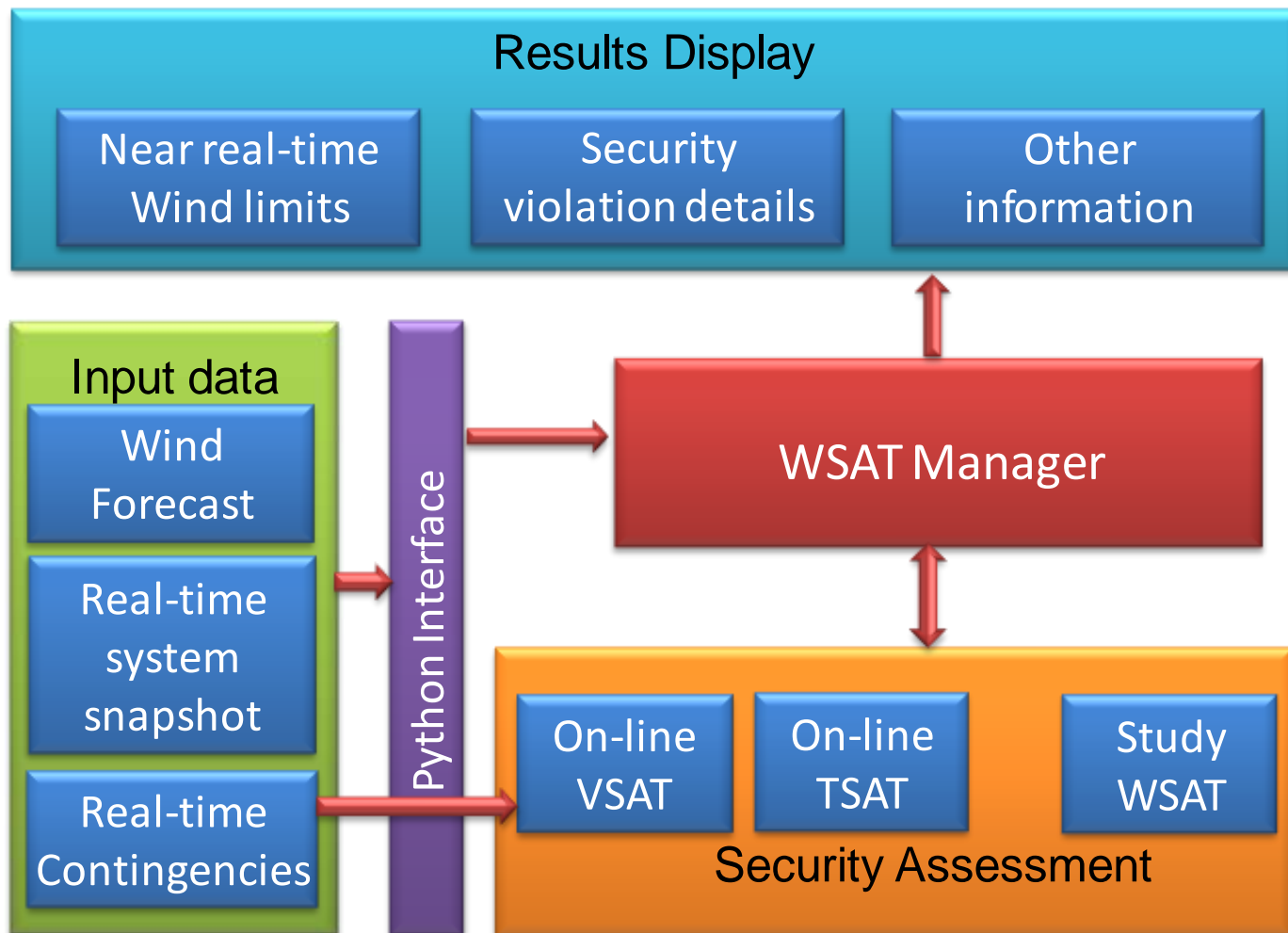
**Nov 2012**

Official  
Launch All-  
island WSAT  
in NCC and  
CHCC

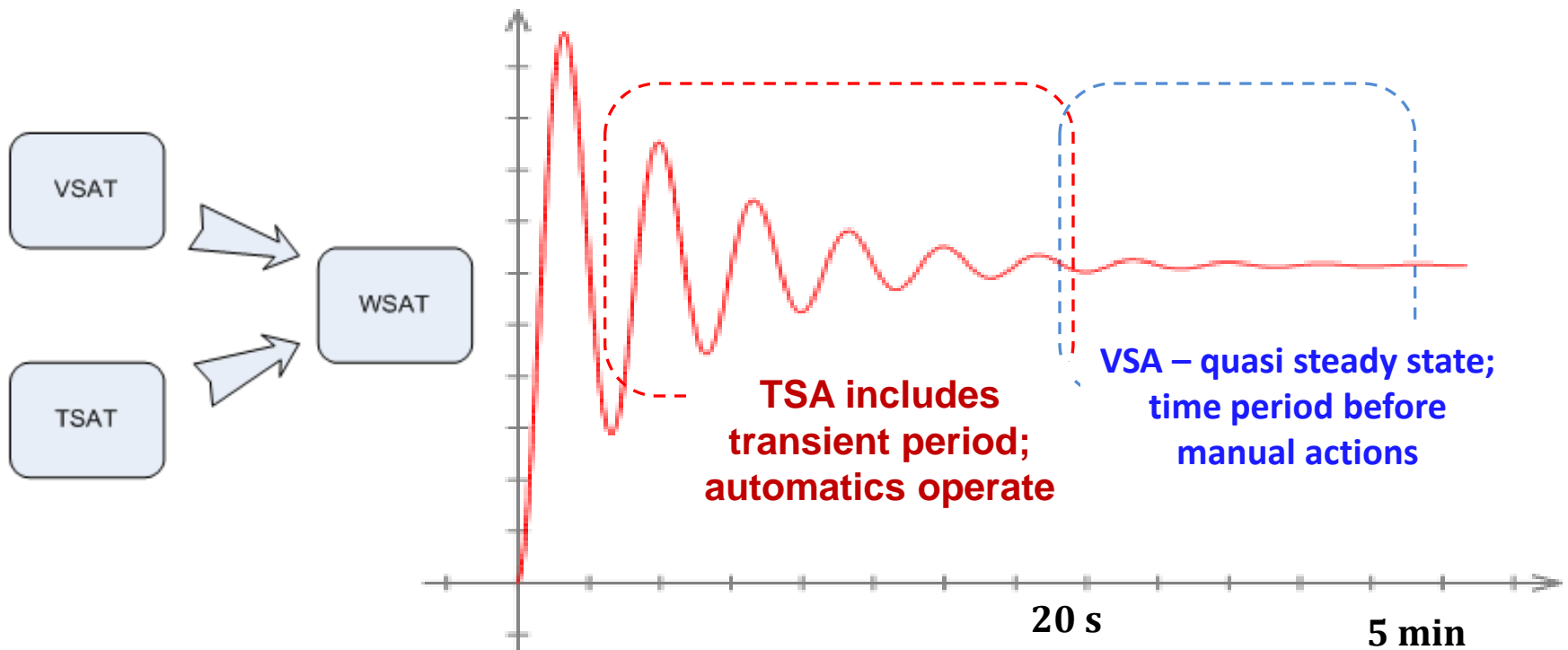
**Nov 2016**

Official  
Launch 5-  
min, new  
EMS-based  
All-island  
WSAT in  
NCC and  
CHCC

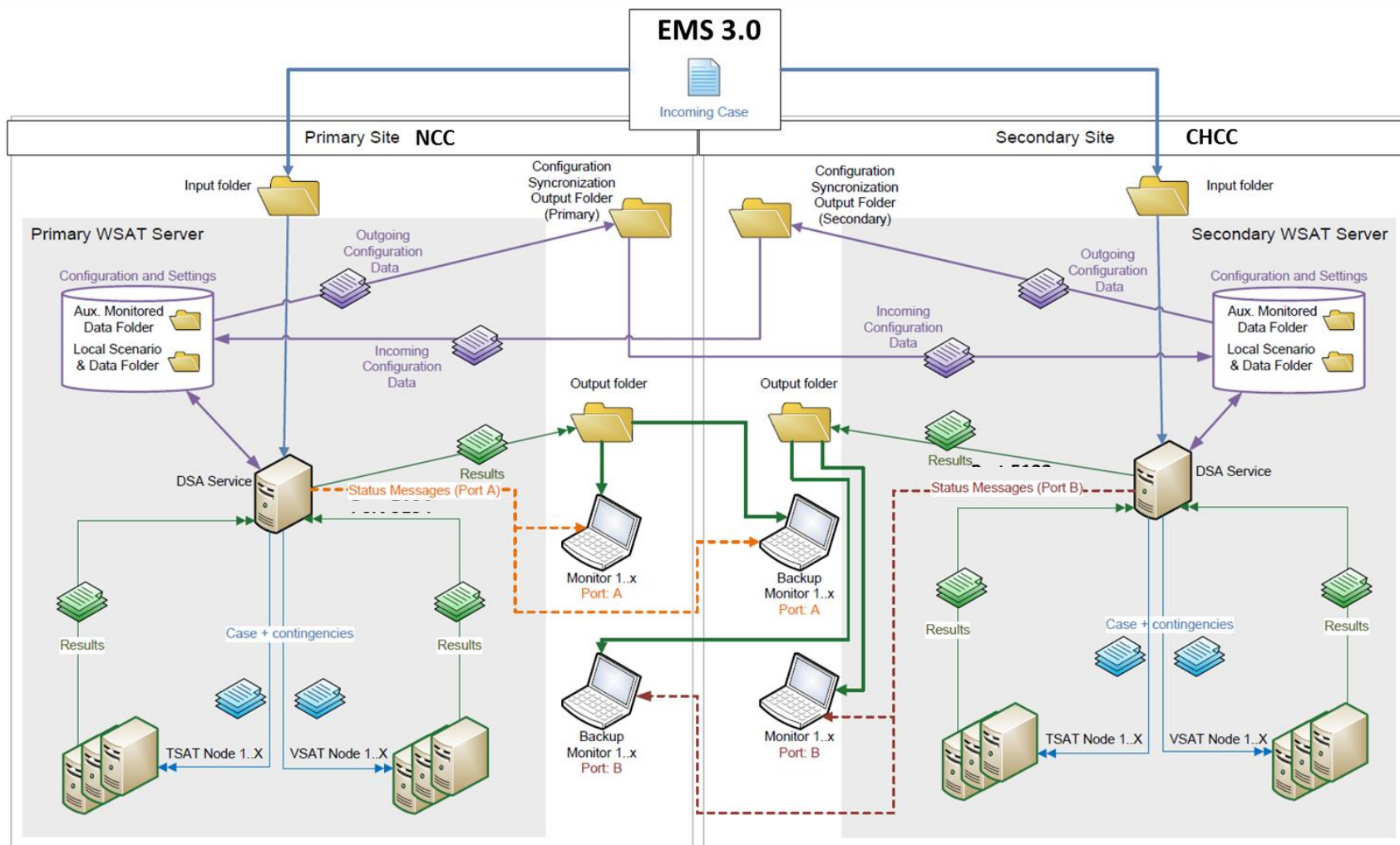
# WSAT – Software Structure



# WSAT Calculations

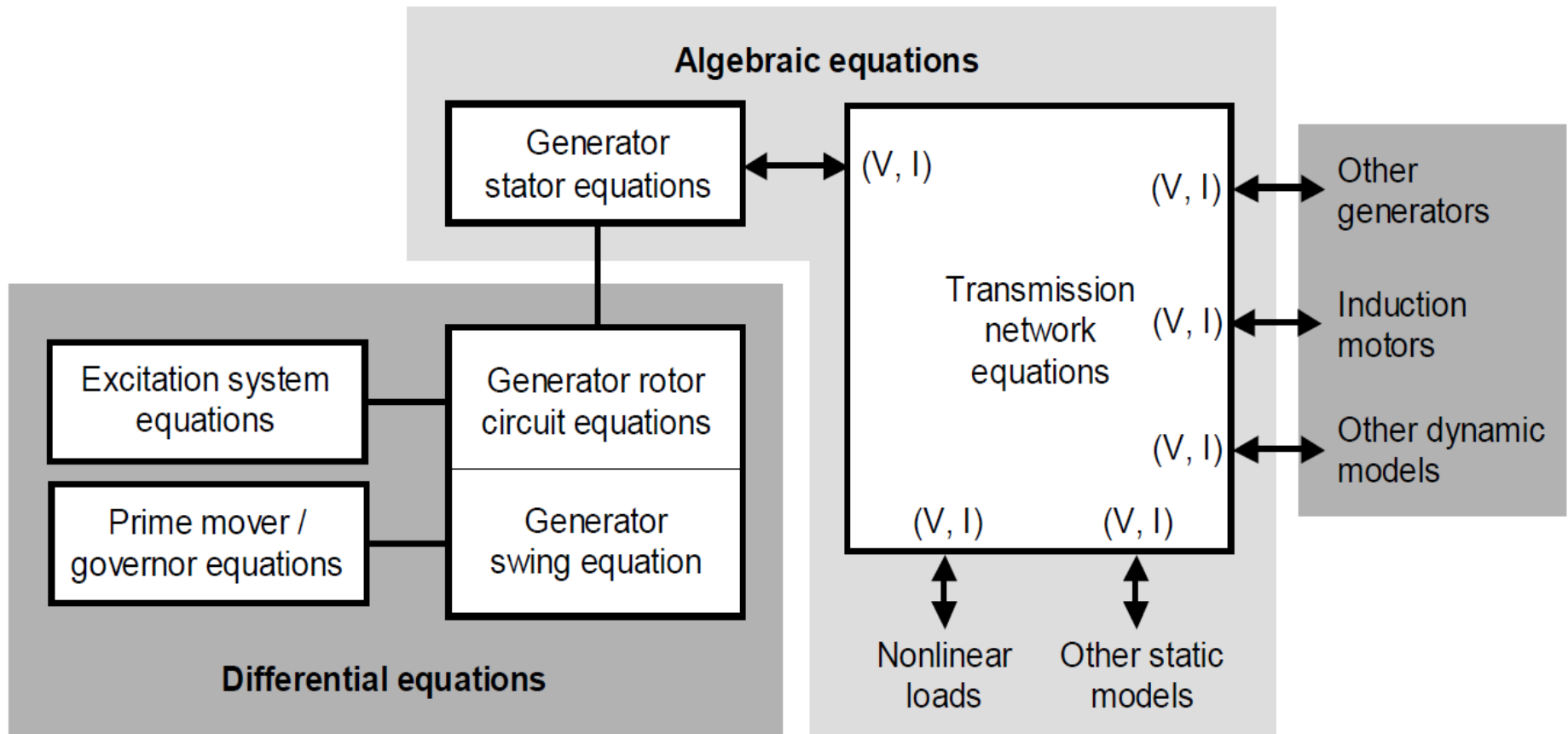


# WSAT – Hardware Architecture



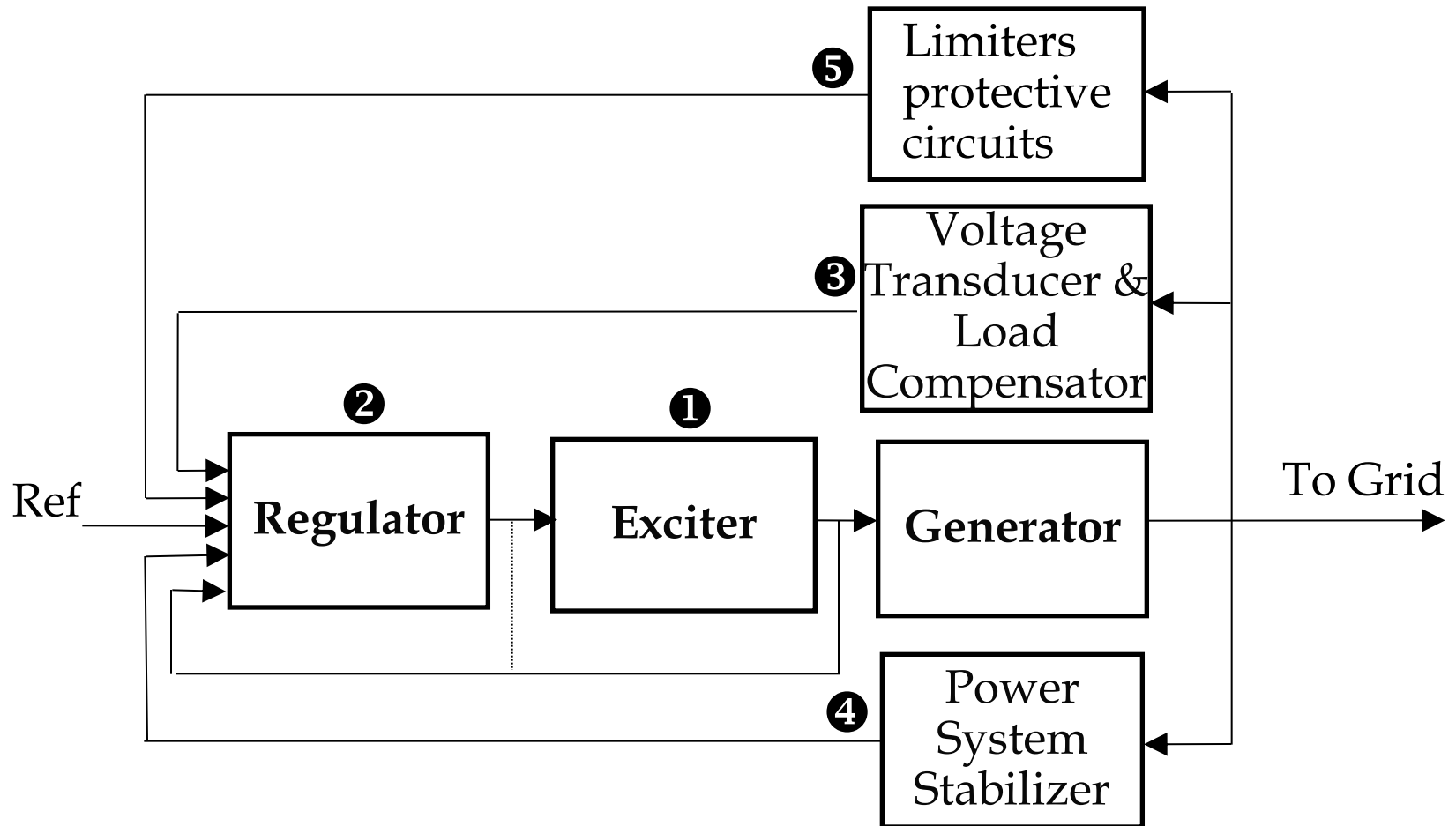


# System Model of Time Domain Simulation

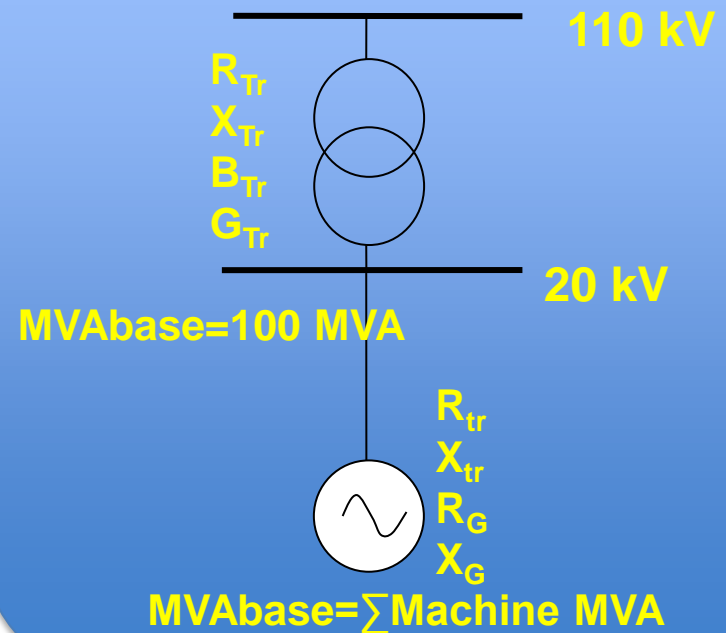
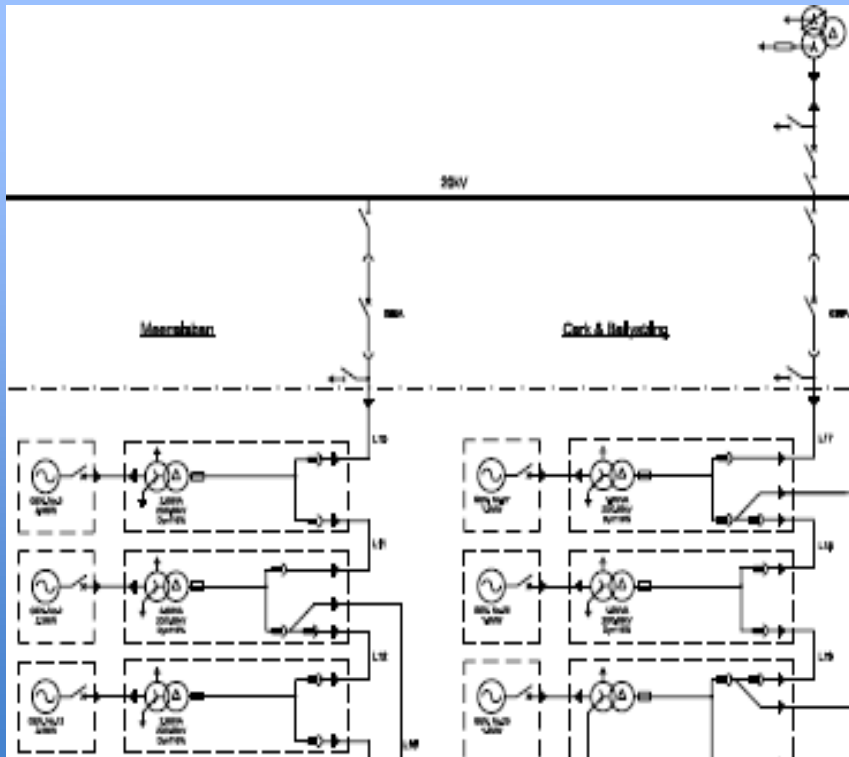




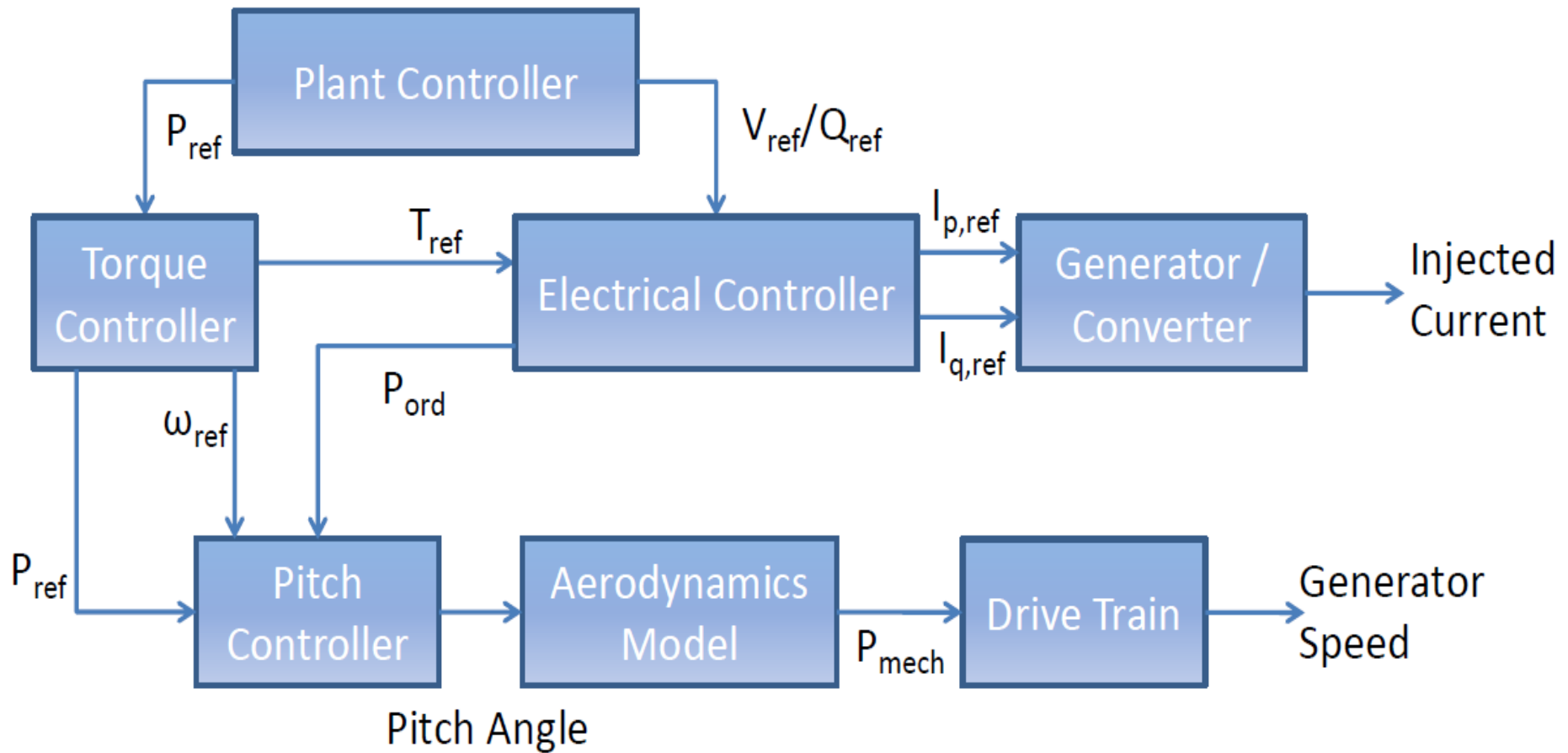
# Elements of an Excitation System



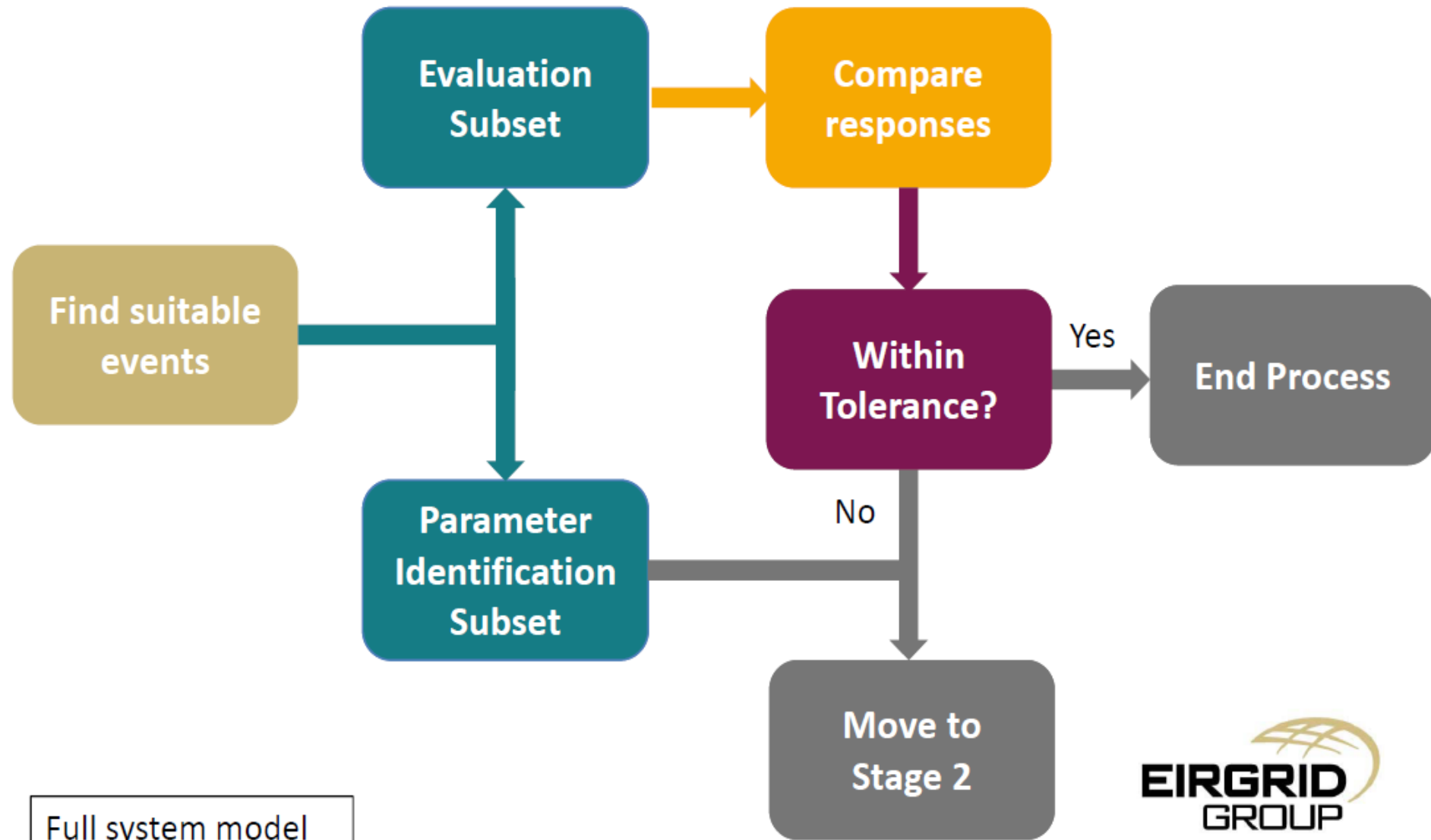
# Detailed and Equivalent WF Model



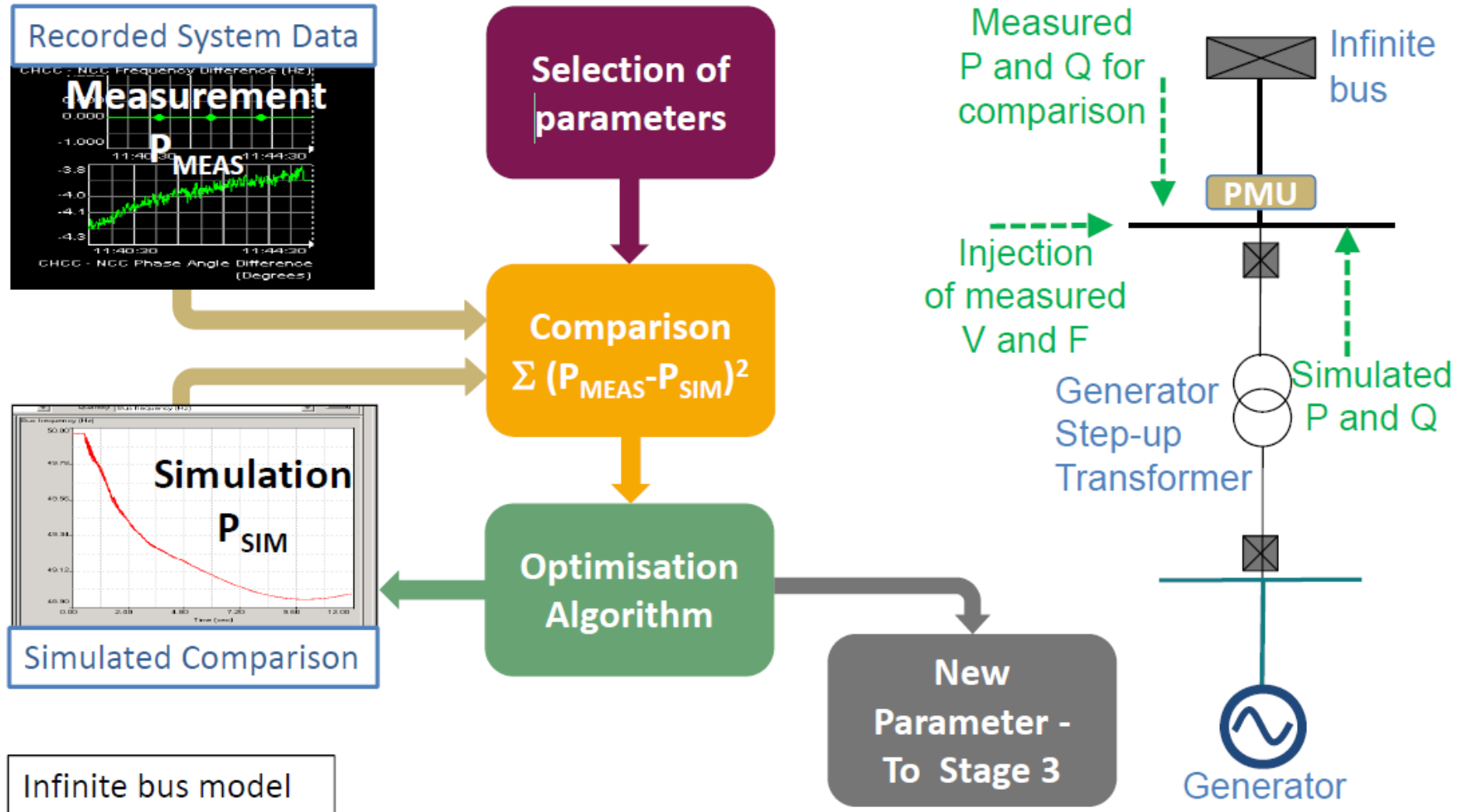
# Second Generation Wind Models (WECC)



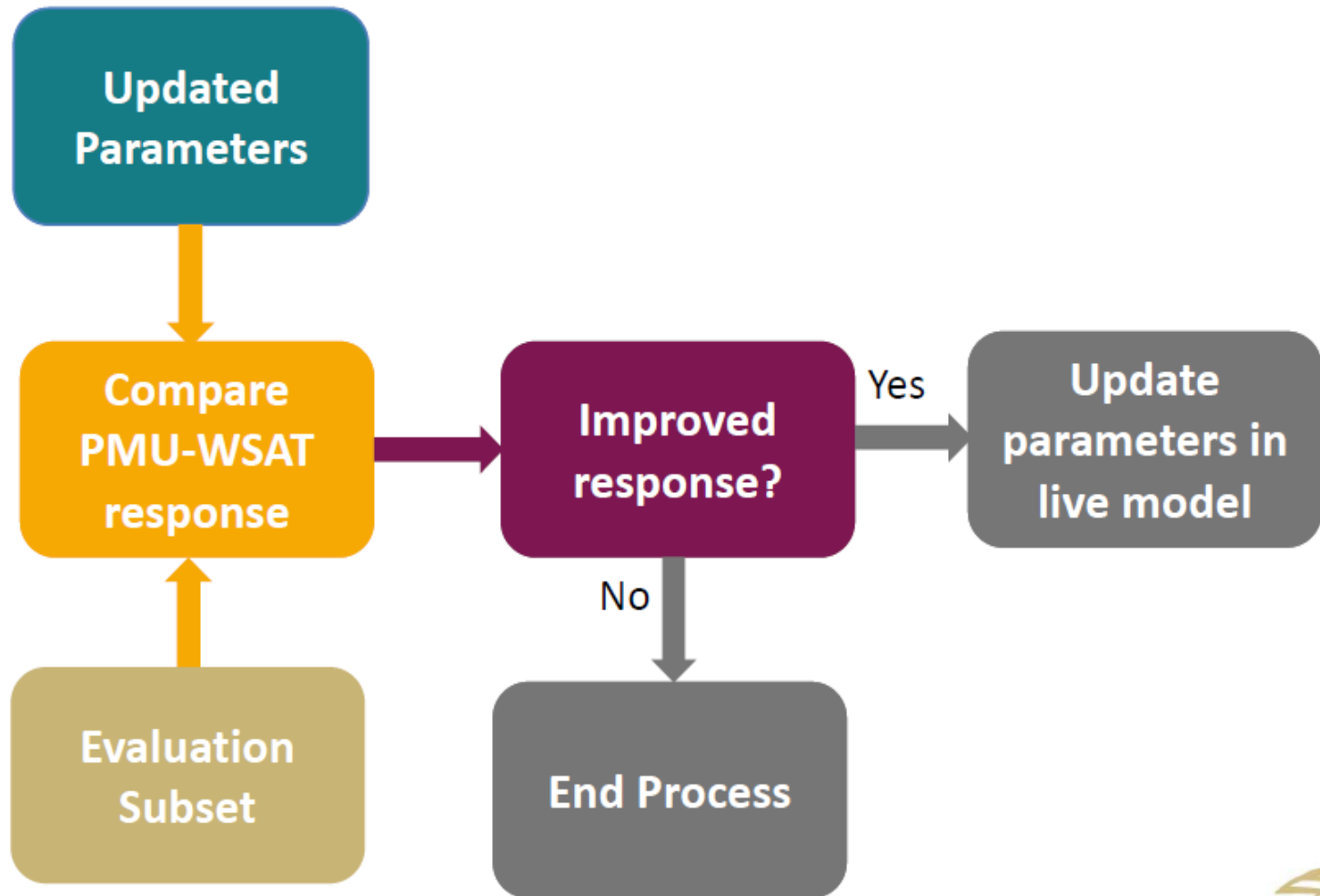
# Model Validation (Stage 1)



# Model Validation (Stage 2)

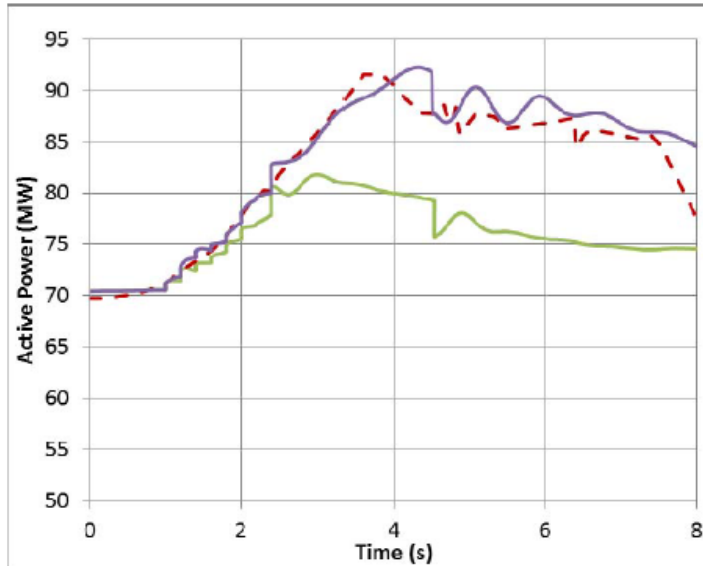


# Model Validation (Stage 3)



Full system model

# Model Validation (Stage 3)

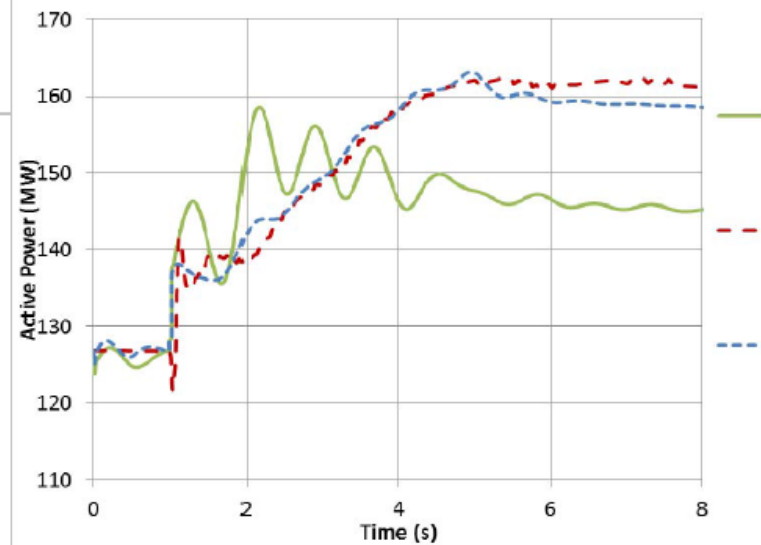


— Original response (MW)

- - - PMU response (MW)

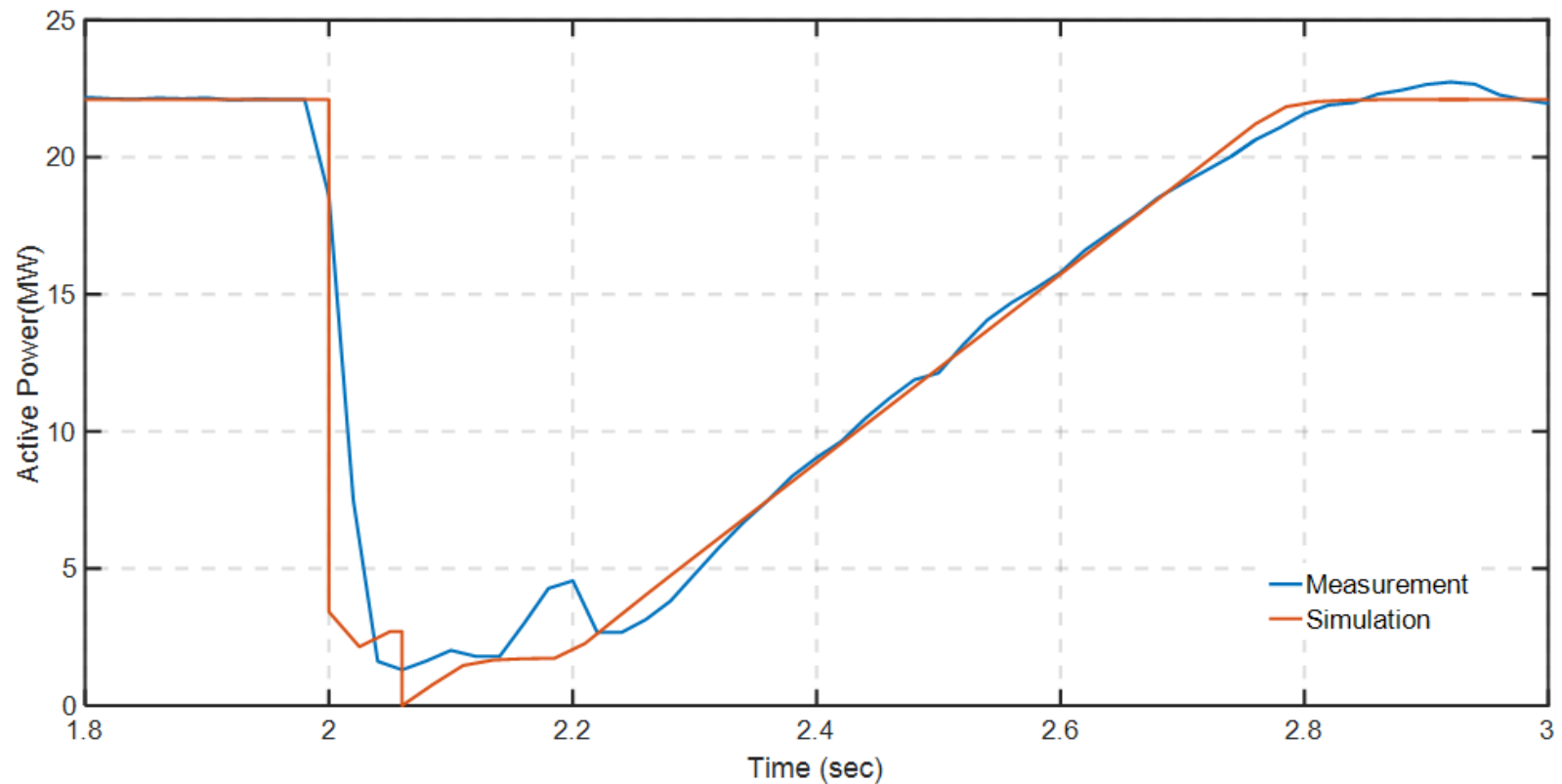
— Tuned response (MW)

(MW)





# North-West Wind Farm Model v Reality



Engineer Operator

--- Configuration Tools ---

Real-Time System

Scenario & Data

Display & Tools

----- Study Tools -----

PSAT Study

VSAT Study

TSAT Study

Last Cycle

Completed 16:37:09

Elapsed 00:02:02

Status Completed

Current Cycle

Start -- : -- : --

Elapsed -- : -- : --

Display

Latest

Hold

Cases

VSAT Viewer

TSAT Viewer

Details

History

Plots

Contingency Analysis Results For Sun,25 Dec, 2016 16:25:00

VSA: SECURE Collapse Voltage

TSA: INSECURE Margin F Drop F Rise

TSA VSA

Insecure Contingencies

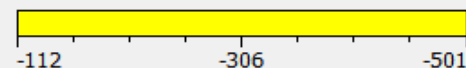
Ct...	Ctg. Name	Security	Margin ...	F Drop ...	F Rise (...)	PCM Scheme
15	IRISHTWN ISHTDB_1NGEN Gen trip	insecure	100.00	1.25	0.00	
25	System Separation	insecure	100.00	2.40	7.13	

Transfer Analysis Results For Sun,25 Dec, 2016 16:25:00

EWIC\_export - Interface: EWIC

Base: -112.1 Limit: -112.1 Details Limiting Factor: CUS1NEW1NFDR

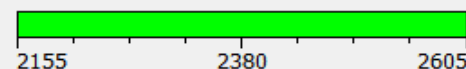
VSA: -112.1 Collapse Dispatch Overload Voltage



Wind Incr. by 450 MW

Base: 2154.7 Limit: 2604.7 Details Limiting Factor:

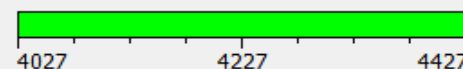
VSA: 2604.7 Collapse Dispatch Voltage SPS



Load Incr. by 400 MW

Base: 4027.1 Limit: 4427.1 Details Limiting Factor:

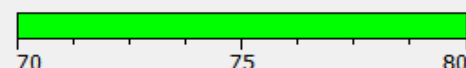
VSA: 4427.1 Collapse Dispatch Voltage



Cauten Wind

Base: 70.3 Limit: 79.9 Details Limiting Factor: Insufficient Dispatchable Reserve

VSA: 79.9 Collapse Dispatch Overload Voltage



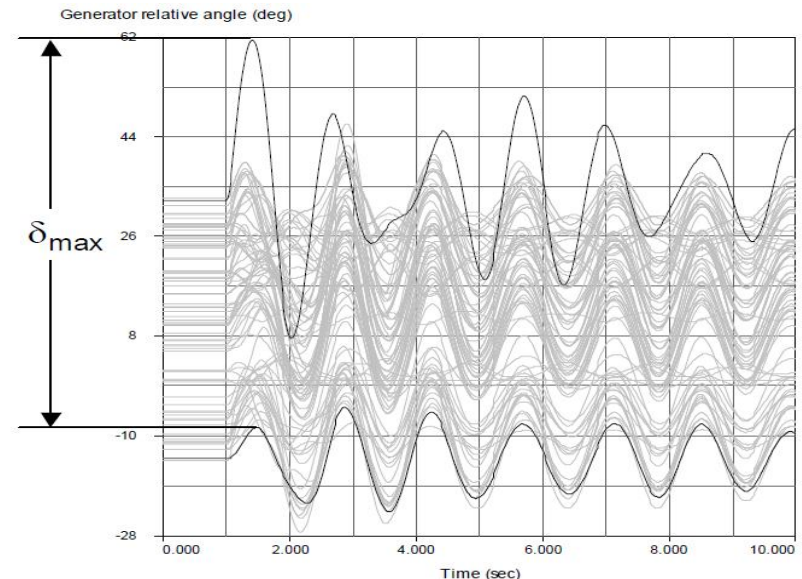
# TSAT Calculations

TSAT Applies faults on each line cleared in accordance to the installed protection (**TSAT Contingencies**)

- Monitors machine rotor angles
- Computes **Transient Stability index for all islands**

$$\eta = \frac{360 - \delta_{\max}}{360 + \delta_{\max}} \times 100$$

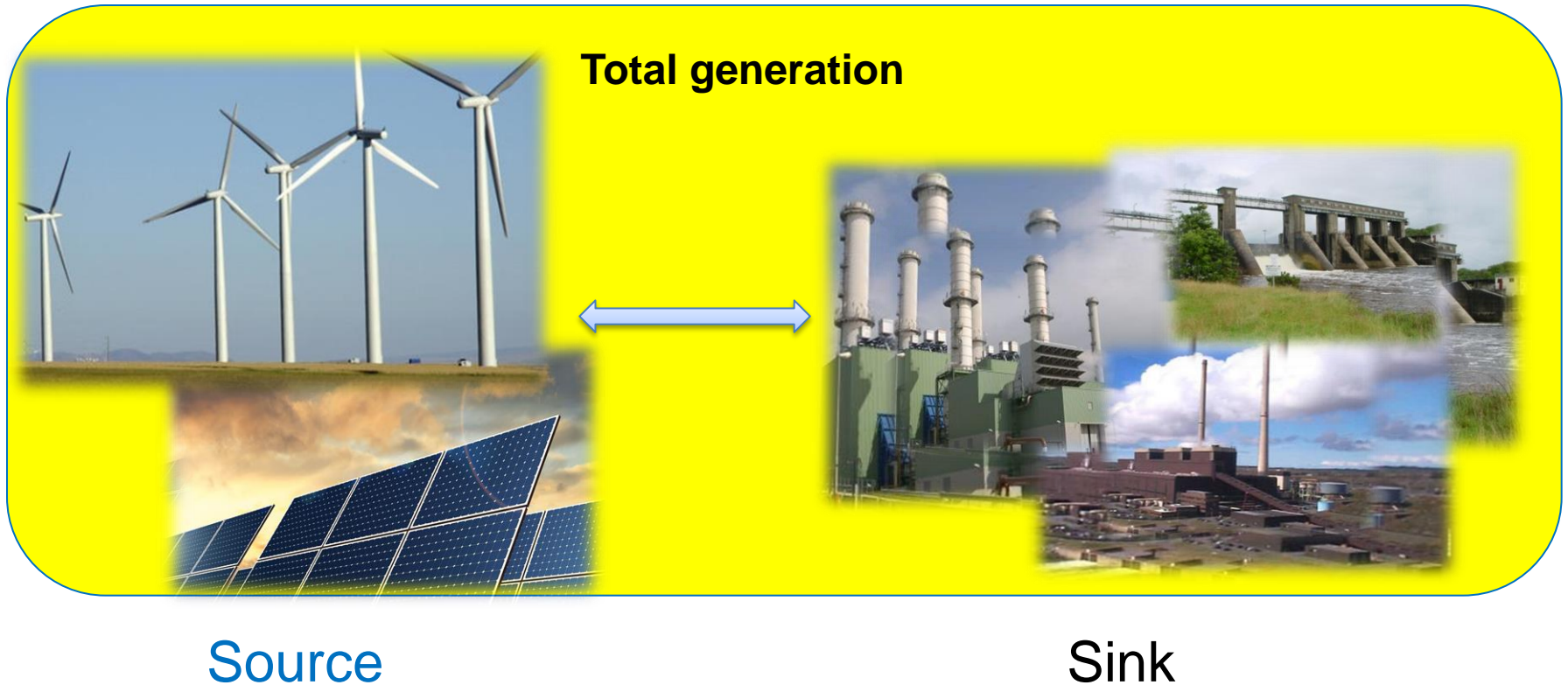
$$-100 < \eta < 100$$



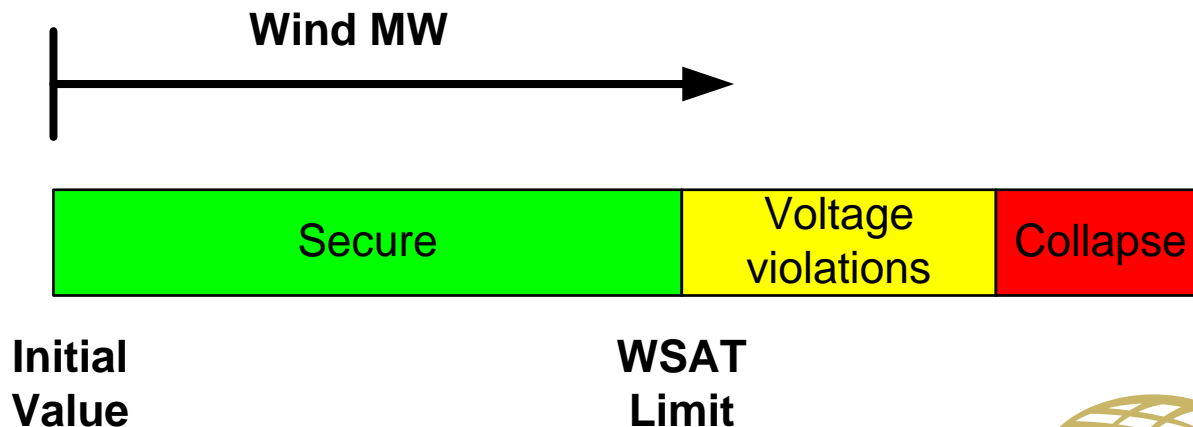
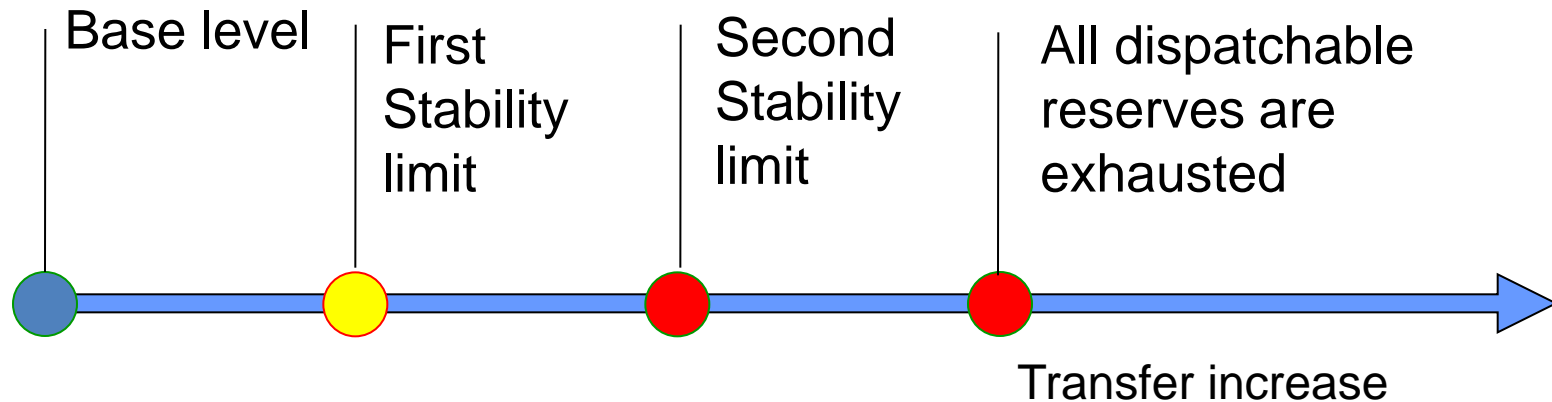
- Attempts to calculate a preventative control measure (PCM), i.e. a recommendation from WSAT on how the instability can be prevented.

# Wind - Conventional generation

## Power Transfer



# Power Transfer: Example of stages



Engineer Operator

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Scenario & Data

Display & Tools

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TSA VSA

Insecure Contingencies

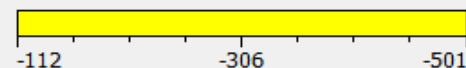
Ct...	Ctg. Name	Security	Margin ...	F Drop ...	F Rise (...)	PCM Scheme
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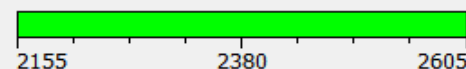
VSA: -112.1 Collapse Dispatch Overload Voltage



Wind Incr. by 450 MW

Base: 2154.7 Limit: 2604.7 Details Limiting Factor:

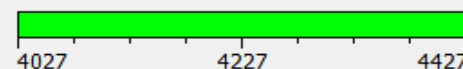
VSA: 2604.7 Collapse Dispatch Voltage SPS



Load Incr. by 400 MW

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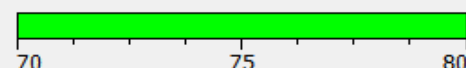
VSA: 4427.1 Collapse Dispatch Voltage



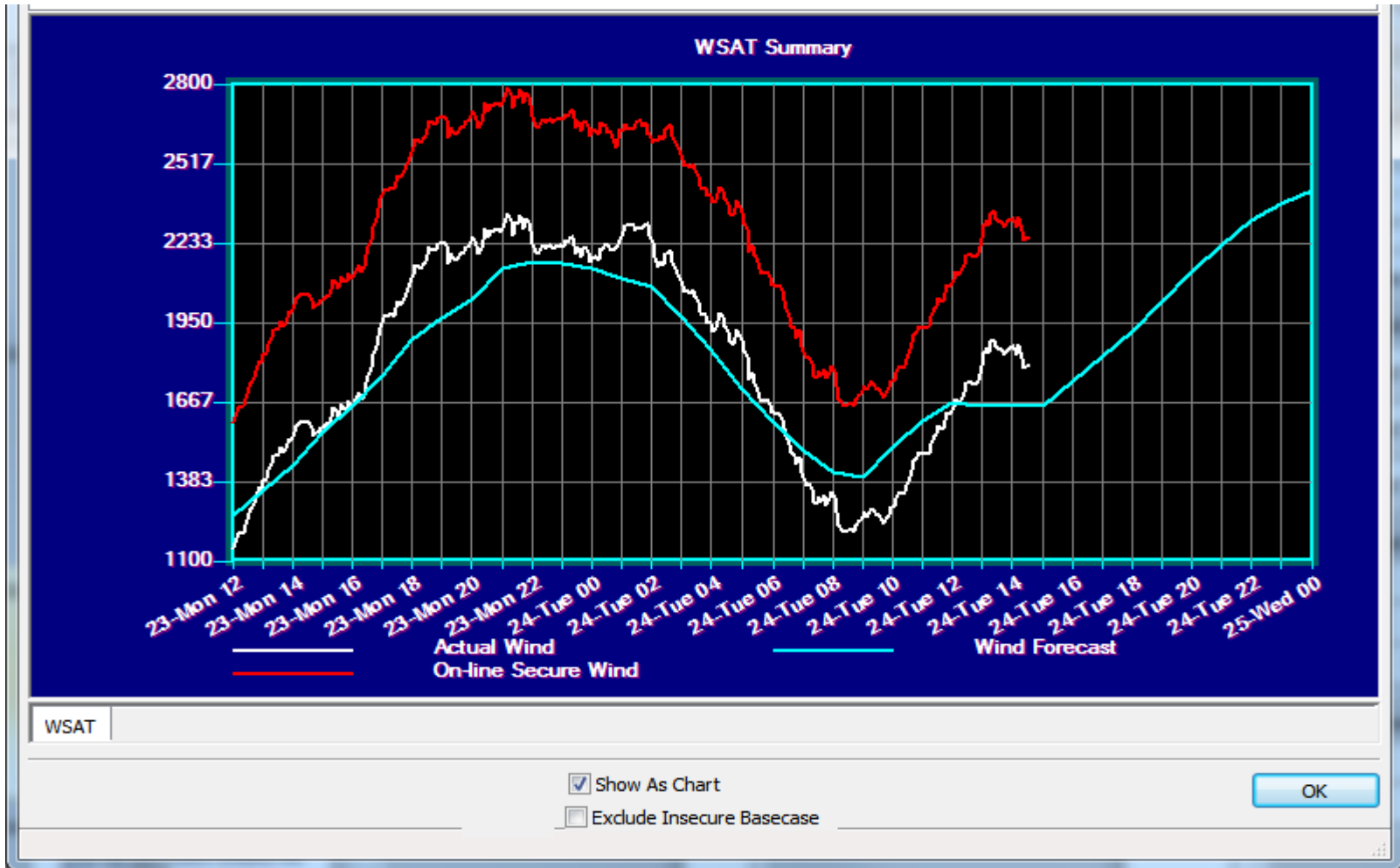
Cauteren Wind

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VSA: 79.9 Collapse Dispatch Overload Voltage



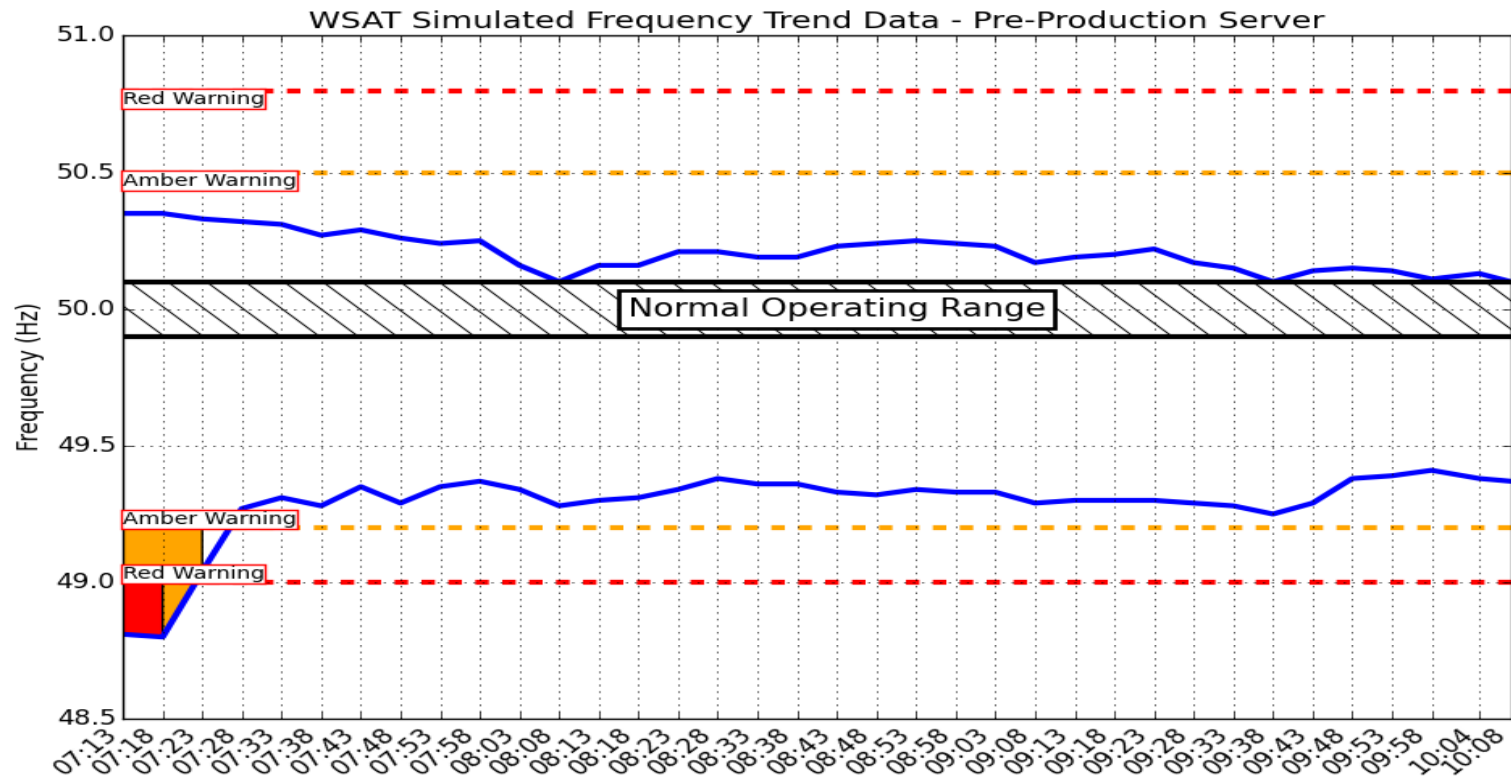
# WSAT Secure Wind graph



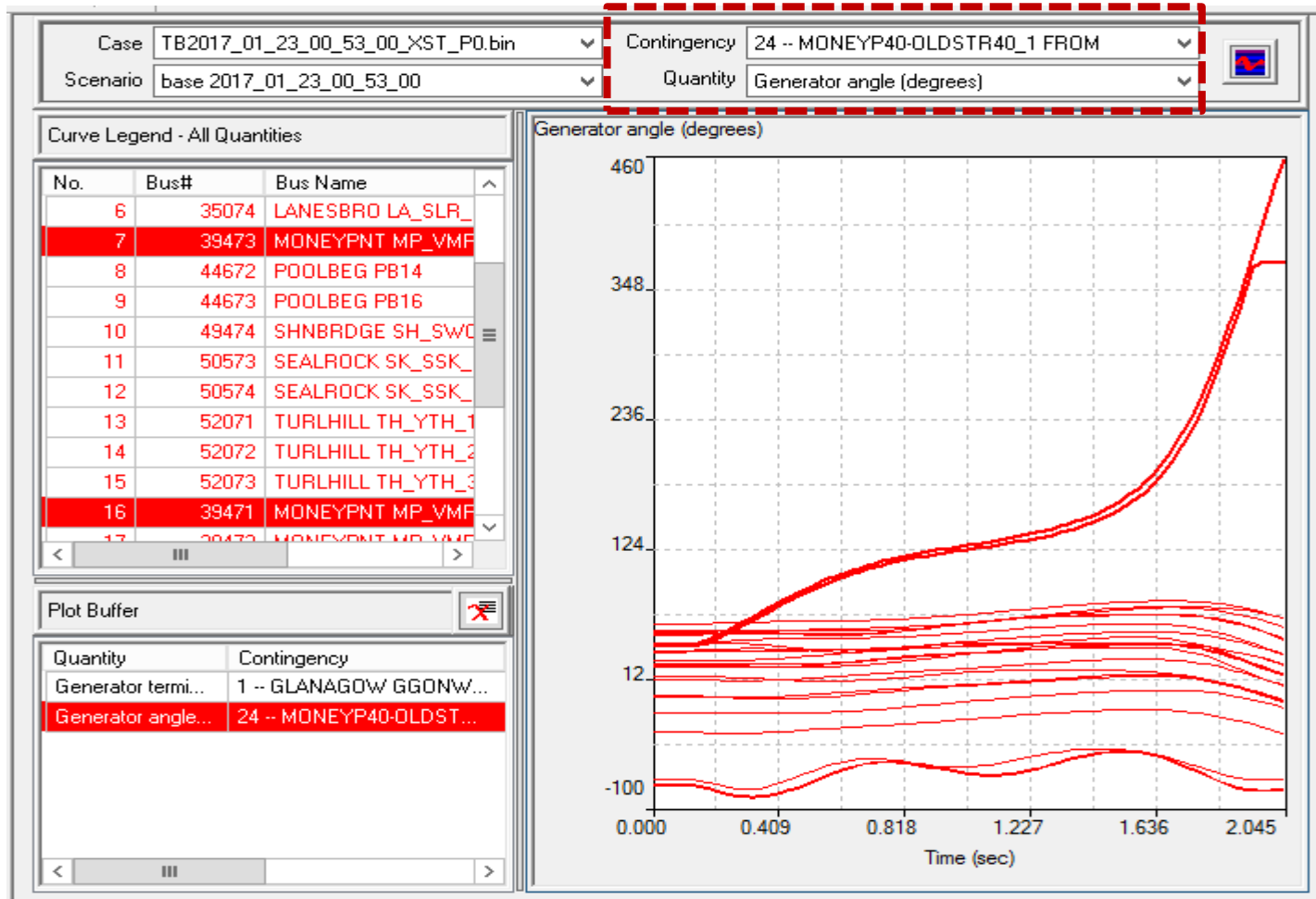


# WSAT Frequency and RoCoF Summary Table

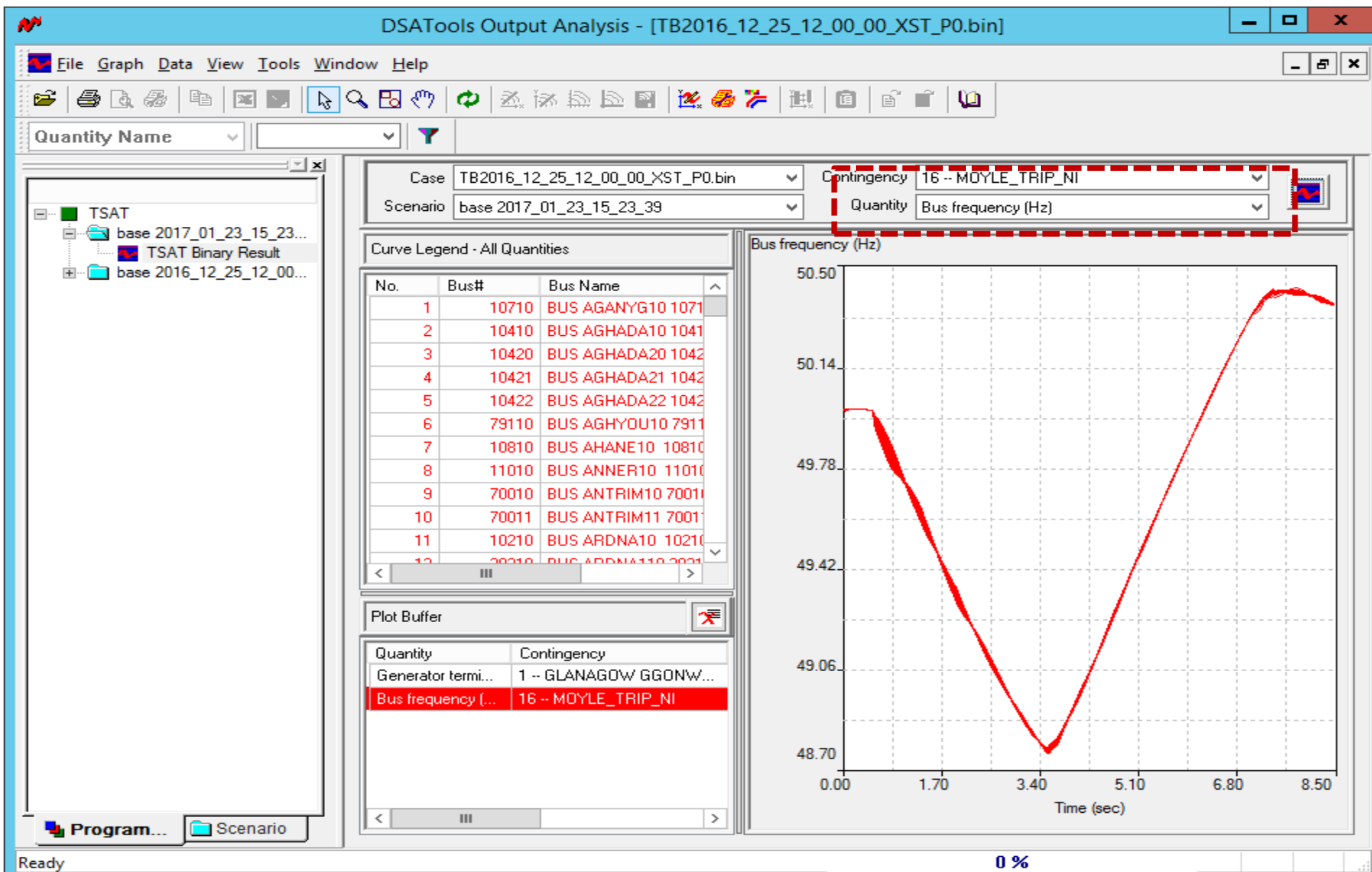
	Frequency				RoCoF			
Simulation Time	Nadir (Hz)	Nadir Contingency	Zenith (Hz)	Zenith Contingency	Negative (Hz/s)	Negative Contingency	Positive (Hz/s)	Positive Contingency
24/01/2017 10:04:00	49.38	GI4	50.13	SYS_S	-0.317	GI4	-	-
24/01/2017 09:58:00	49.41	GI4	50.11	EWIC_P	-0.311	GI4	-	-
24/01/2017 09:53:00	49.39	GI4	50.14	SYS_S	-0.31	GI4	-	-
24/01/2017 07:23:00	49.04	SYS_S	50.33	SYS_S	-0.477	SYS_S	0.202	SYS_S
24/01/2017 07:18:00	48.8	SYS_S	50.35	SYS_S	-0.661	SYS_S	0.226	SYS_S
24/01/2017 07:13:00	48.81	SYS_S	50.35	SYS_S	-0.653	SYS_S	0.22	SYS_S



# Transient Insecurity Example



# Frequency Insecurity Example





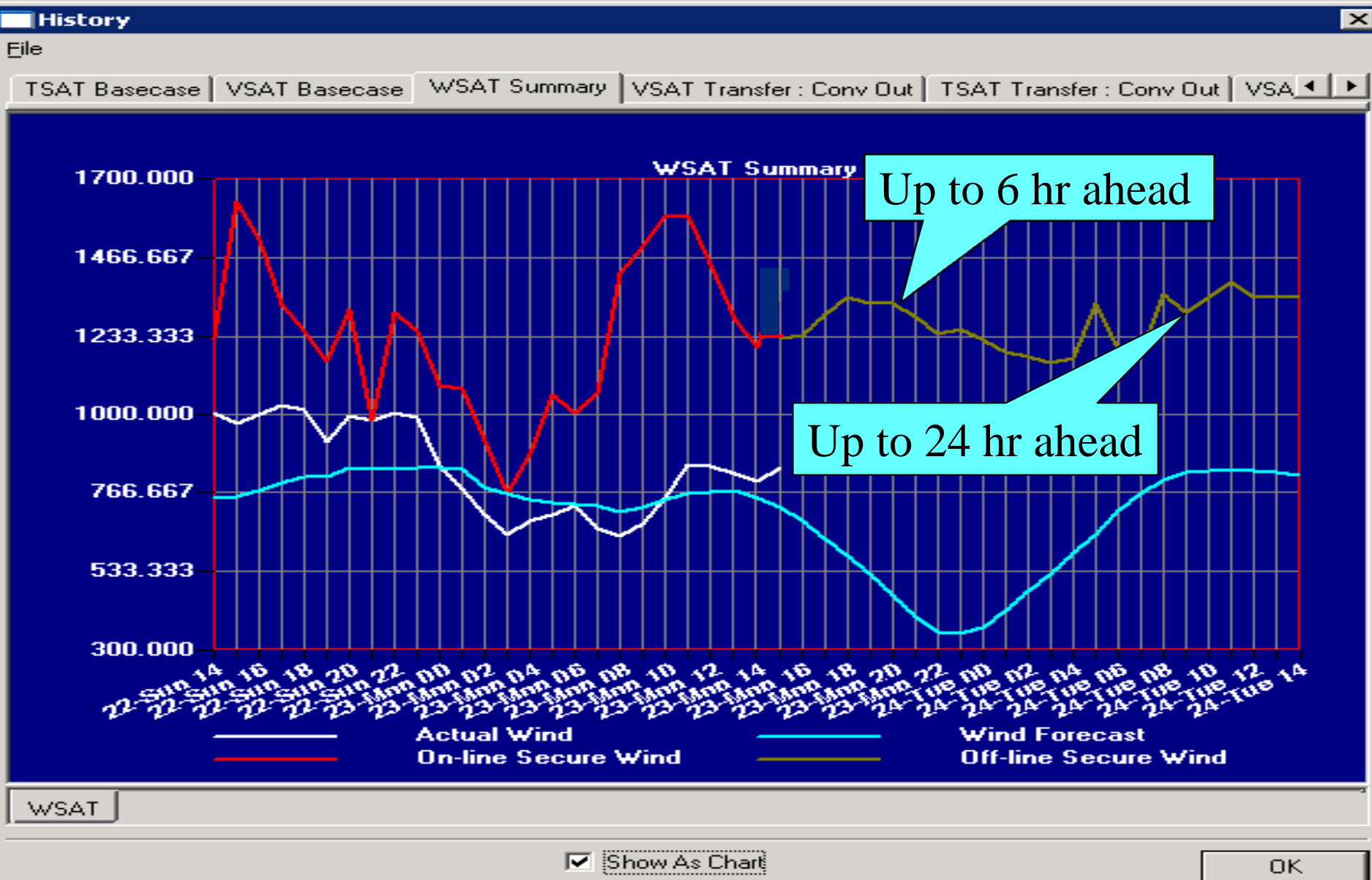


# Did You Know?

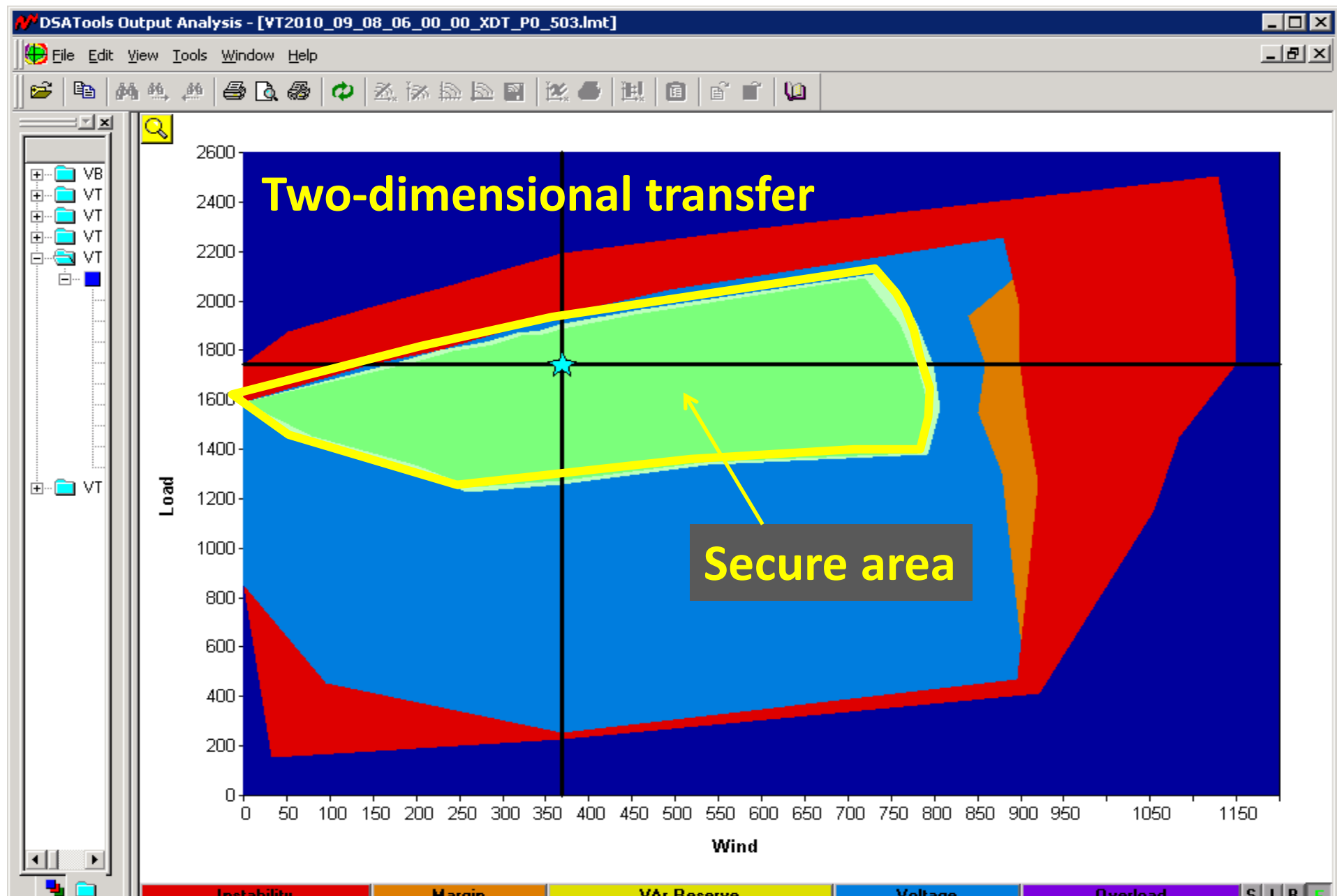


- WSAT (Wind Security Assessment Tool), used in the EirGrid Control Centres, helps deliver on our strategy to be a world leader in the integration of renewables on to the power system across the island of Ireland.
- WSAT now runs every 5 minutes, meaning **4.5 million** unique operational security tests are carried out every day.
- WSAT now has site hardware and application redundancy to reflect it's growing criticality in power system operations.
- A cross-functional team from HR&CS and OPI were involved in the delivery of this significant project – Well done to all involved!

# Combined Real-time and Forecast WSAT



# 2-D Transfers



# Questions?