WTG Dynamic Exercises

Standardized Wind Turbine Generator WTG dynamic models have been developed and adopted by WECC.

Manufacturer-specific dynamic models typically take the form of either user-written and/or black-box models and pose many complications when applied to large interconnected regional models.

WECC have developed models, that are public (non-proprietary), that are available as standard-library models, and have been tested and validated in accordance to WECC guidelines.

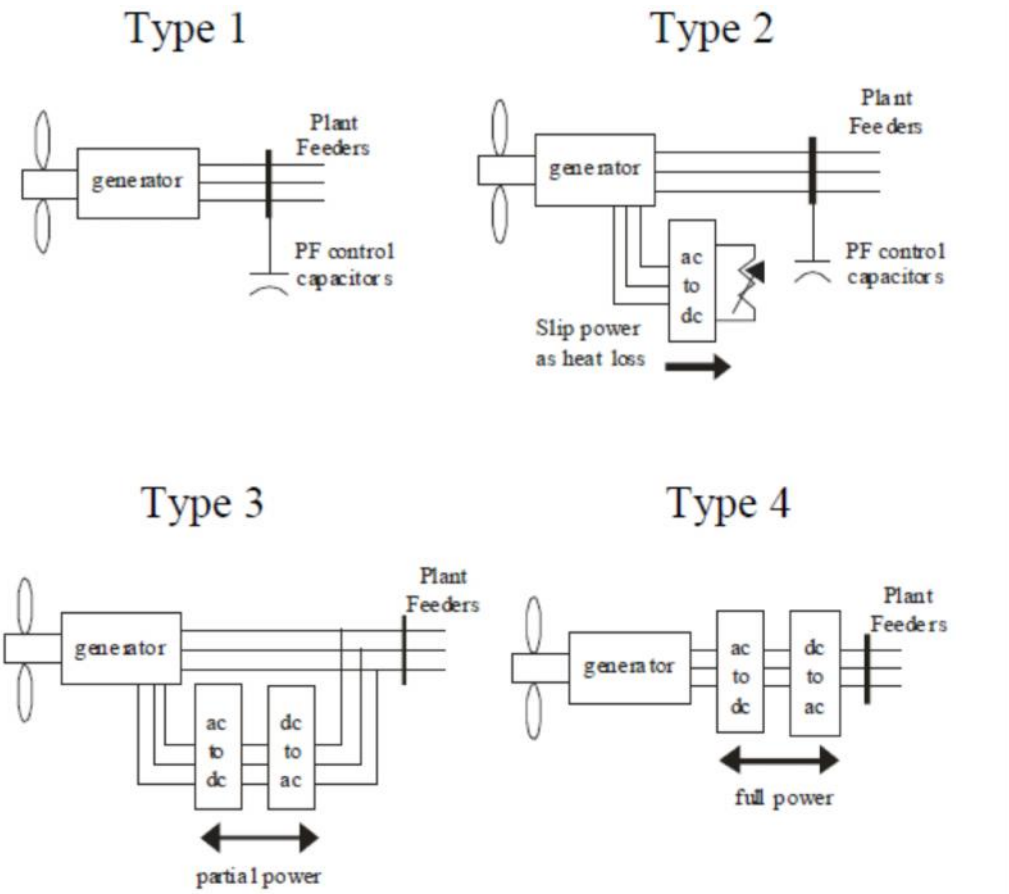
Approved models are listed in the WECC Approved Dynamic Model List.

The WTG dynamic study exercises are developed as a guide for the application of the wind power plant generic dynamic models that are suitable for representation of wind power plants that use Type 1, Type 2, Type 3 or Type 4 wind turbine generators.

The WTG rating is in the range of 1 to 5 MVA. And these use one of the wind turbine-generator (WTG) technologies listed below.

- Type 1 – Fixed-speed, induction generator
- Type 2 – Variable slip, induction generators with variable rotor resistance
- Type 3 – Variable speed, doubly-fed asynchronous generators with rotor-side converter
- Type 4 – Variable speed generators with full converter interface

WTG Dynamic Exercises



Classification of WTGs Based on Generator Topology and Grid Interface

TYPE 1 WTG

A Type 1 WTG is an induction generator with relatively simple controls. The torque speed characteristic is very steep (about 1% slip at rated torque), which means that these generators operate at nearly constant speed.

As with any induction generator, the Type 1 WTGs absorb reactive power.

Most commercial Type 1 WTGs use multiple stages of switched capacitor banks at the turbine terminals to correct the steady-state power factor at the WTG terminals to unity, over the range of power output. With a slow varying wind speed, the individual capacitors switch in and out.

A large temporary reactive power imbalance can occur due to changes in wind speed or grid conditions.

At high speed Type 1 WTGs use pitching to effect stall. Blade pitching also contributes to stability following a fault.

TYPE 2 WTG

Type 2 WTGs are also directly-coupled induction generators and use power factor correction capacitors.

However, the dynamic behavior is different because they can rapidly adjust the effective rotor resistance with power electronics.

The rotor resistance control (fast) and the pitch control (slower) work in concert to

- control speed,
- reduce mechanical stress,
- and improve stability during a disturbance.

WPPs with Type 1 and Type 2 WTGs typically have plant-level reactive compensation equipment to meet steady-state and dynamic reactive power requirements.

External reactive support also helps the plant meet low voltage ride-through requirements.

The steady-state and dynamic characteristics of Type 3 and Type 4 WTGs are dominated by the power converter. The converters allow the machine to operate over a wider range of speeds, and control active and reactive power independently, so long as the total current output of the unit is within the current limits of the converter.

This means that Type 3 and Type 4 WTGs have the capability to participate in steady-state and dynamic volt/var control.

Type 3 and Type 4 WTGs also use blade pitch control to optimize energy capture.

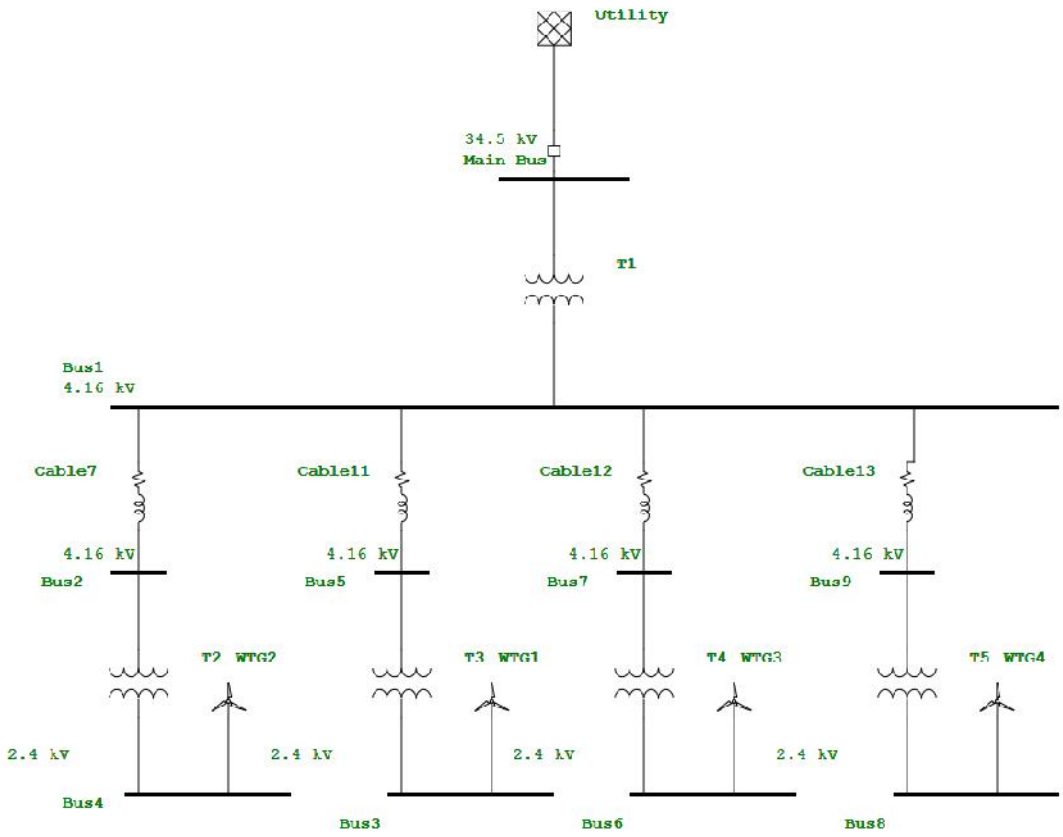
It should be noted, however, that in some cases with Type 3 and Type 4 WPPs plant level reactive compensation – typically in the form of mechanically switched capacitors controlled through a plant level controller – is also deployed, since it is in some cases not possible to effectively translate all the reactive capability of the WTGs, acting through the collector system at the point of common coupling.

Because they use grid-side voltage-source power converters, Type 3 and Type 4 WTGs tend to be more flexible in terms of reactive power control and disturbance tolerance. Even so, wind power plants that use Type 1 and Type 2 WTGs can be designed to have comparable

performance by supplementing them with external plant-level reactive-power support devices such as STATCOMs and SVCs.

WTG Exercise – Open the WTG Exercise files under sub-folder WTG Examples

The exercise includes a wind power plant with many WTGS as in figure attached.



The objective is to assess dynamic performance of the system, particularly recovery dynamics following distribution bus and WTG terminal faults as well as during wind disturbances such as ramp or gust of wind. The models have active power, reactive power, voltage and pitch control along with low voltage ride-through feature.

ETAP allows use of both Generic, WECC as well as USER DEFINED models as can be seen in the exercises attached.

WTG Dynamic Exercises

The models used as black box with sample data in ETAP is as summarised in table below-

ETAP WTG Control Model Types Generic & WECC Types			
WTG Type	**Control**	**Control Type-Wind & Pitch**	**Operating Mode**
1	Generic	NA	NA
	WECC	WT1	Induction Generator
2	Generic	NA	NA
	WECC	WT2	Induction Generator
3	Generic	Type 1	Mvar Control
	WECC	WT3	Voltage Control
4	Generic	NA	NA
	WECC	WT4	Voltage Control

WTG Transient Studies IN Renewable Folder With WTG Sub Folder				
Folder	**OTI File**	**WTG Control Model selected for the study**	**Case Study Event**	**Observe Response Of Results--**
WG_Fault Bus	WG-04	Type 3 - Generic	Faults & Main Bus & at WTG Terminal	WTG Mechanical Power & Speed
				WTG Electrical Power & Speed
				ETG Reactive Power & Voltage
				WTG Wind Speed & Pitch
WG_Wind Chg	WG-02		Wind Ramp	WTG Wind Speed & Pitch
				WTG Mechanical Power & Speed
				WTG Electrical Power & Speed
				ETG Reactive Power & Voltage

The above WG_FaultBus case has also been evaluated using UDM modelling of Wind turbines with reference to WECC Guidelines. An example of the study case “WG_FaultBusUDM” is provided in the project folder for reference.