AESO Information Session on Transmission System Modelling

August 12, 2021

Grid Reliability

Using Zoom

- All attendees will join the meeting in listen-only mode, with attendee cameras disabled and microphones muted.
- When asking or typing in a question, **please state your first and last name and the organization you represent**.
- Two ways to ask questions during the presentation if you are accessing the meeting using your computer or smartphone:
  - You can **click the icon to raise your hand** and the host will see that you have raised your hand. The host will unmute your microphone. You in turn will need to unmute your microphone and then you can ask your question. Your name will appear on the screen but your camera will remain turned off.
  - You can also ask questions by **typing them into the Q&A window**. Click the “Q&A” button next to “Raise Hand.” You’re able to up-vote questions that have been already asked.

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  - You can also ask questions by tapping the “Q&A” button and typing them in. You’re able to up-vote questions that have been already asked.

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- Using the Zoom app on a smartphone:
  - Tap “Raise Hand.” The host will be notified that you've raised your hand.
  - Tap “Lower Hand” to lower it if needed.
  - You can also ask questions by tapping the “Q&A” button and typing them in. You’re able to up-vote questions that have been already asked.

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- If you are accessing the webinar via conference call:
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- Phone controls for attendees:
  - To raise your hand, on your phone's dial pad, hit ∗9. The host will be notified that you've raised your hand.
  - To toggle between mute and unmute, on your phone's dial pad, hit ∗6.

AESO Stakeholder Engagement Framework

Stakeholder participation

- The participation of everyone here is critical to the engagement process. To ensure everyone has the opportunity to participate, we ask you to:
  - Listen to understand others' perspectives
  - Disagree respectfully
  - Balance airtime fairly
  - Keep an open mind

Welcome and Introductions

AESO meeting representatives

- Ping-Kwan Keung, Manager, Standards & Modeling
- Karim Shaarbafi, Senior Engineer

Disclaimer

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Purpose of this session

- Provide information on transmission modelling in both providing transmission modelling data to be included in the system model and usage of the system model in transmission studies.
- Provide information on update to the system modelling practice to incorporate new technologies.
- Provide updates and answer stakeholder questions on representations of:
  - STATCOMs for Alberta transmission system studies;
  - Energy Storage Resources for Alberta transmission system studies; and
  - Distribution Energy Resources for transmission system studies including the use of power factor control mode for synchronous machines
- Introduce the modelling consideration of Transient Overvoltage study on transmission system
- Overview of the changes introduced in the 2021 Planning Base Cases Suite

Agenda

Item	Agenda Item
1	Introduction
2	Update on representation of STATCOMs for Alberta transmission system studies • SMART VALVE • Questions and discussion
3	Update on representation of Energy Storage Resources for Alberta transmission system studies • Questions and discussion
4	Update on representation of Distribution Energy Resources for transmission system studies including the use of power factor control mode for synchronous machines • Overview of Typical DER Model in ID #2010-001R • Questions and discussion
5	Introduction on the modelling consideration of Transient Overvoltage (TOV) study on transmission system. • Questions and discussion
6	Overview on the changes introduced in 2021 Planning Base Cases Suite. • Questions and discussion

Registrants (As of Aug. 8, 2021)

- Alberta Newsprint
- Alberta Utilities Commission
- AltaLink
- ATCO Electric
- Aura Power Renewables Ltd.
- Bema (CCA)
- BluEarth Renewables
- Brookfield Renewable
- CanREA
- CCA
- City of Lethbridge
- City of Medicine Hat
- CNRL
- Consulting Engineer
- Customized Energy Solutions
- DePal Consulting Limited
- Dow Chemical Canada ULC
- Eaton/ETEG
- Enel NA
- ENMAX Energy Corporation
- ENMAX Power Corporation
- EPCOR Utilities Inc
- Green Cat Renewables Canada Corp
- Heartland Generation Ltd.
- IBI Group
- IPPSA
- Lionstooth Energy Inc.
- MATL Canada/MATL LLP
- Patriot Energy Marketing Inc.
- PGSC
- PowerEN Corporation
- Stantec Consulting Ltd.
- Suncor Energy Inc.
- TC Energy
- The City of Red Deer
- TransAlta Corporation
- UCA
- University of Alberta
- URICA Asset Optimization
- Walker Industries

Static Compensators Modelling

(STATCOMs) for Alberta transmission system studies

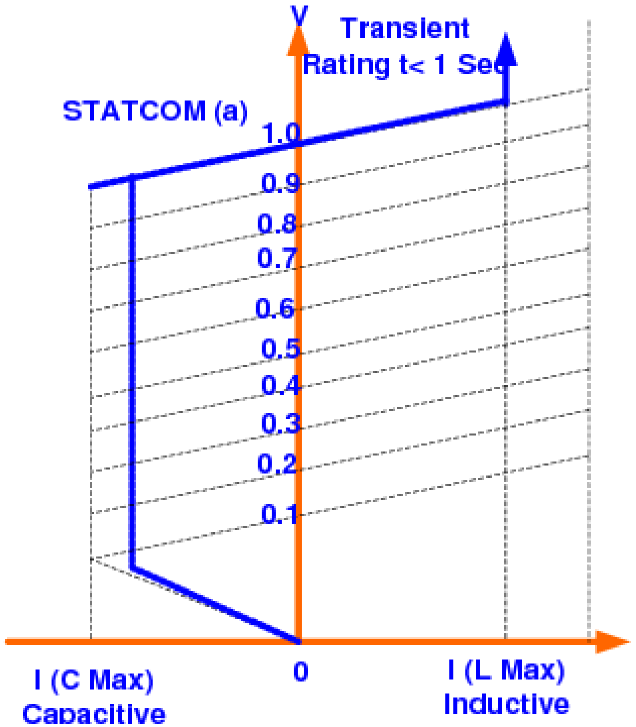
Public

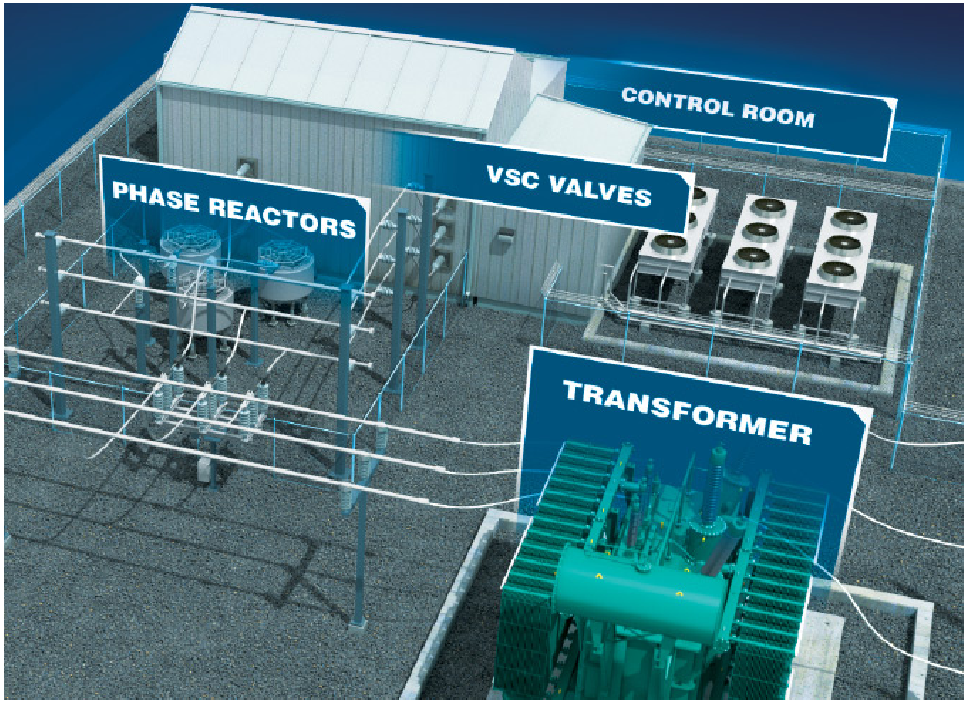
Topics

- What are STATCOMs?
- STATCTOM’s Load Flow model in PSSE
- SVCs Generic Models
- SVSMO3 Limitations
- SVSMO3 model for STATCOMS
- AESO Challenges in Thickwood Hills STATCOM

What are STATCOMs?

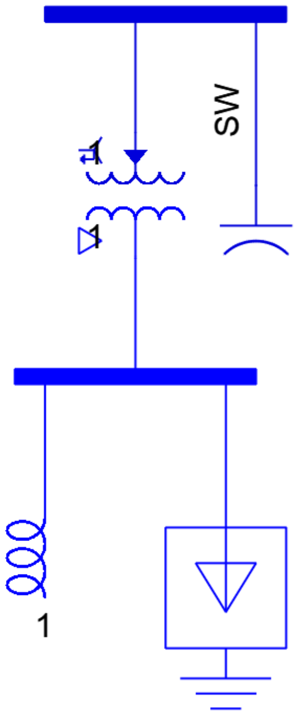
- STATCOMs are
  - Static Synchronous Compensators or condenser
  - Shunt connected FACTS devices
  - Voltage source converter
- VI Characteristics

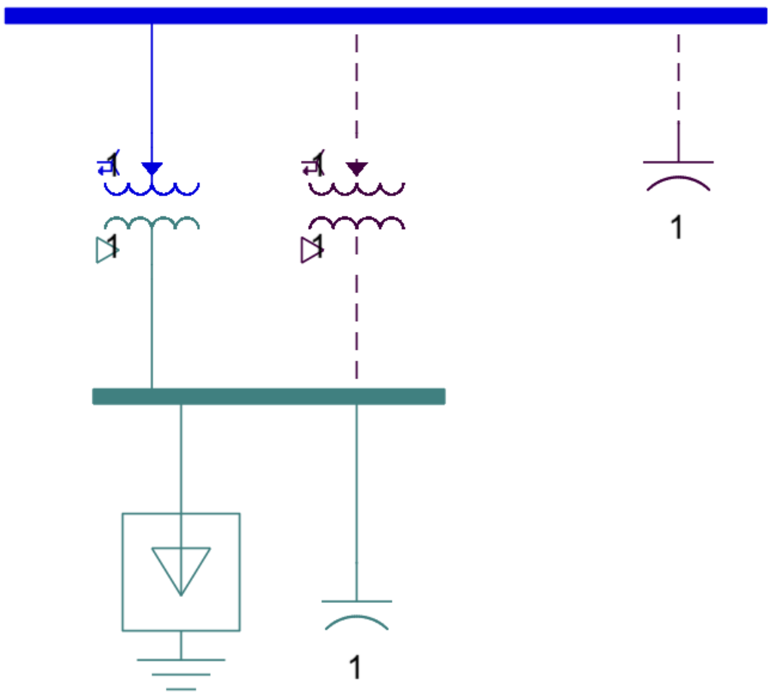




What are STATCOMs?

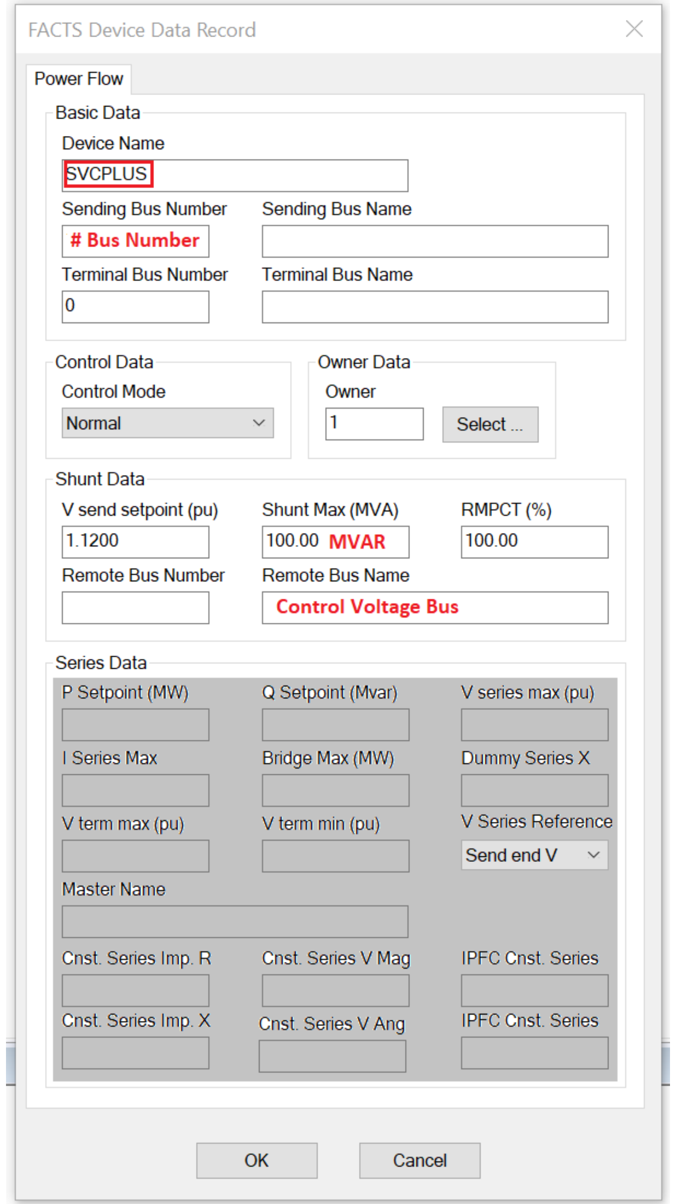
- STATCOMs are usually expensive devices.
- To reach to higher reactive capability, they are usually used in parallel with SVCs such as TSC, TCRs or (Mechanical) Switched Capacitors





STATCTOM's Load Flow model in PSSE

- Modeled as FACTS Devices,
- A name is assigned for each STATCOM
- Max Shunt MVAR is defined
- A remote Bus to control its voltage can be defined otherwise 0 means the STATCOM bus voltage is controlled
- Series data section is ignored



Static VAR Compensators Generic Models

- The generic developed models for different types of SVCs:

	Type of SVC	Dynamics Model
1	TCR Based SVC	SVSMO1
2	TSC/TSR SVC	SVSMO2
3	VSC based SVC (STATCOM) Voltage Source Converter	SVSMO3

- SVSMO3U2 in PSSE/V33 and SVSMO3T2 in PSSE/V34.6
- For more information about its operation and control logic please refer to WECC document "**Generic Static Var System Models**" in the following link:

  https://www.wecc.org/Reliability/WECC-Static-Var-System-Modeling-Aug-2011.pdf

SVSMO3 Limitations

- Present Symmetrical reactive power capability:
  - STATCOMs have symmetrical capabilities such as ±100 MVAR
- Can control (switch On/Off) up to 8 reactor or capacitor as Mechanically Switched Shunt (MSS) devices. They should be modeled as fixed shunt capacitor or reactor with an ID
- Can not represent switching of TSC/TSR and Fixed Shunt Capacitor/Reactor at the same time. Because it has only one switching time entry for MSS. TSC/TSR are switched In/Out very fast but MSSs are slow

SVSMO3 model for STATCOMS

- Integer Constants

ICON	Value	Description
M		Remote bus number for voltage regulation
M+1		Disable or enable coordinated MSS switching, 0 - no MSS switching, 1 - MSS switching based on STATCOM current
M+2		flag1, slow-reset off/on, flag1 (0/1)
M+3		flag2, non-linear droop off/on, flag2 (0/1)
M+4		1st MSS bus #
M+5		1st MSS Id (to be entered within single quotes)
M+6		2nd MSS bus #
M+7		2nd MSS Id (to be entered within single quotes)
M+8		3rd MSS bus #
M+9		3rd MSS Id (to be entered within single quotes)
M+10		4th MSS bus #
M+11		4th MSS Id (to be entered within single quotes)
M+12		5th MSS bus #
M+13		5th MSS Id (to be entered within single quotes)
M+14		6th MSS bus #
M+15		6th MSS Id (to be entered within single quotes)
M+16		7th MSS bus #
M+17		7th MSS Id (to be entered within single quotes)
M+18		8th MSS bus #
M+19		8th MSS Id (to be entered within single quotes)

SVSMO3 model for STATCOMS

- Constants

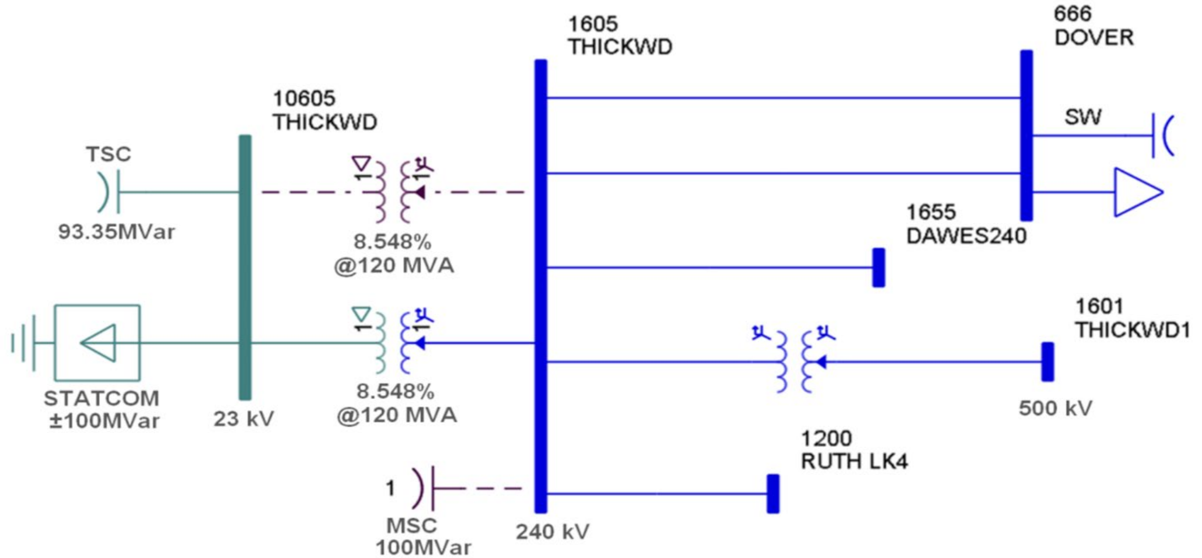
CONs	Value	Description
J+13		K_Ir, Integral gain for slow-reset control
J+14		Idbd, Deadband range for slow-reset control (pu on STBASE)
J+15		Vr_{max}, Max. limit on slow-reset control output (pu)
J+16		Vr_{min}, Min. limit on slow-reset control output (pu)
J+17		Max. short-term current rating as a multiplier of max. continuous current rating pu
J+18		UV_1, Voltage at which STATCOM limit starts to be reduced linearly (pu)
J+19		UV_2, Voltage below which STATCOM is blocked (pu)
J+20		OV_1, Voltage above which STATCOM limit linearly drops (pu)
J+21		OV_2, Voltage above which STATCOM blocks (pu)
J+22		Vtrip, Voltage above which STATCOM trips after time dealy, Tdelay2 (pu)
J+23		Tdelay1, duration of short-term rating(sec)
J+24		Tdelay2, Trip time for V > Vtrip (sec)
J+25		Vrefmax, Max. voltage reference limit (pu)
J+26		Vrefmin, Min. voltage reference limit (pu)
J+27		Tc2, lead time constant (sec)
J+28		T_b2, lag time constant (sec)
J+29		I2t, short-term limit
J+30		Reset, Reset rate for I2t limit
J+31		hyst, Width of hysteresis loop for I2t limit
J+32		Xc1, Non-linear droop slope 1
J+33		Xc2, Non-linear droop slope 2
J+34		Xc3, Non-linear droop slope 3
J+35		V_1, Non-linear droop upper voltage (pu)
J+36		V_2, Non-linear droop lower voltage (pu)
J+37		Tmssbrk, time for MSS breaker to operate - typically ignore (sec)
J+38		Tout, Time MSC should be out before switching back in (sec)
J+39		TdelLC, time delay for switching in a MSS (sec)
J+40		Iupr, Upper threshold for switching MSSs (pu on STBASE)
J+41		Ilwr, Lower threshold for switching MSSs (pu on STBASE)
J+42		Sdelay, time for which STATCOM to remain blocked before being un-blocked (sec)
J+43		STBASE(>0), STATCOM base MVA

Transmission System Model for Thickwood Hills STATCOM

- Reactive devices in Thickwood:

	Component	Capacity [MVar]	Operating Voltage [kV]	Bus Nominal Voltage [kV]	Load Flow Model	Dynamics Model
1	Voltage source STATCOM	± 100	23	23	FACTs Device	SVSMO3
2	Thyristor Switched Capacitor bank (TSC)	+100	23	23	Switched Shunt	Fixed Shunt Capacitor controlled by SVSMO3
3	Mechanical Switched Capacitor bank	+100	260	240	Fixed Shunt Capacitor	Uncontrolled Fixed Shunt Capacitor

- Topology of Thickwood SVS with its associated devices and the vicinity area

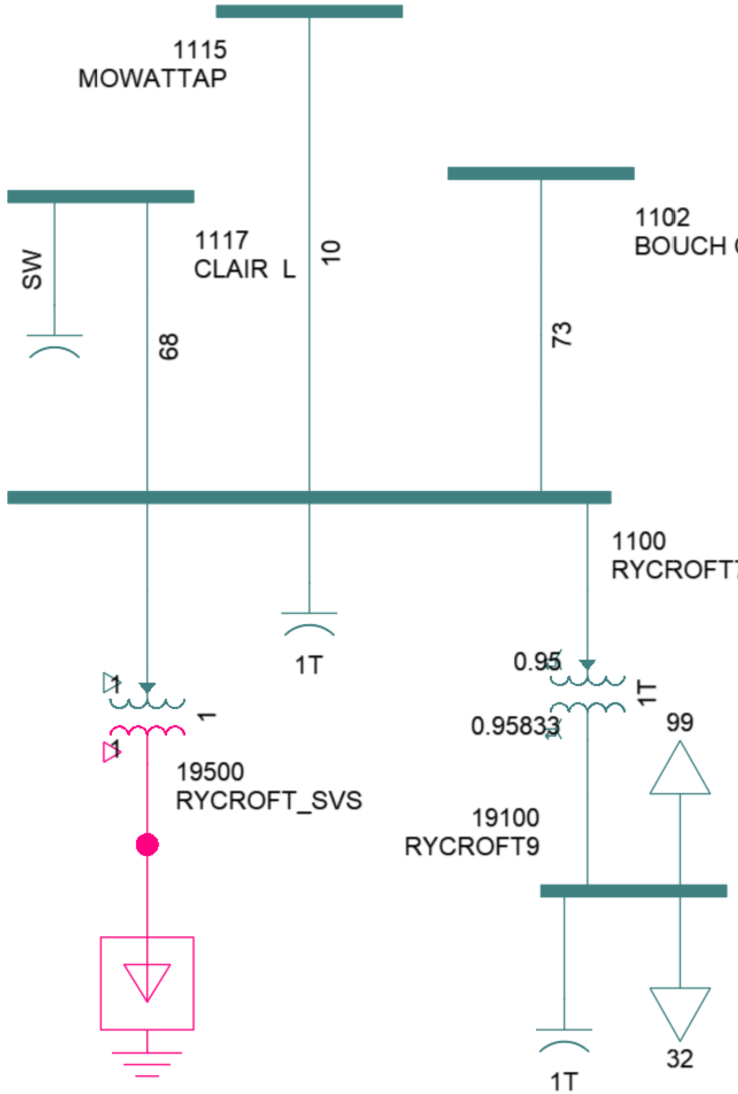


Thickwood Hills STATCOM Operation

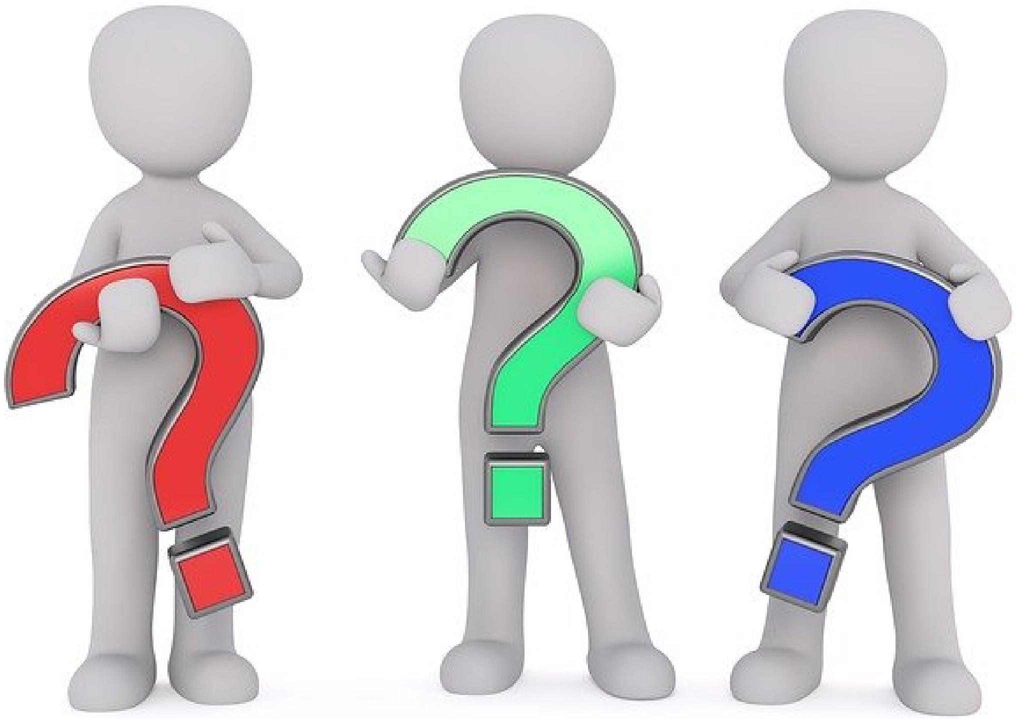
- Controls voltage at 240 kV bus (# 1605) at voltage setpoint of 1.12 pu via:
  – Continuous control with STATCOM
  – switching in or out of Thyristor Switched Capacitor (TSC) with sub-cycle switching time
  – Mechanical Switched Capacitor (MSC) with 180 to 240 cycles delayed switching in automatic and fast control mode.
- All are controlled by STATCOM Controller in system

Rycroft STATCOM

- ± 50 Mvar Dynamics Reactive Power Support Device
- Connected to 138 kV system at 730S Rycroft Substation



Questions and discussion



SMART VALVE

Topics

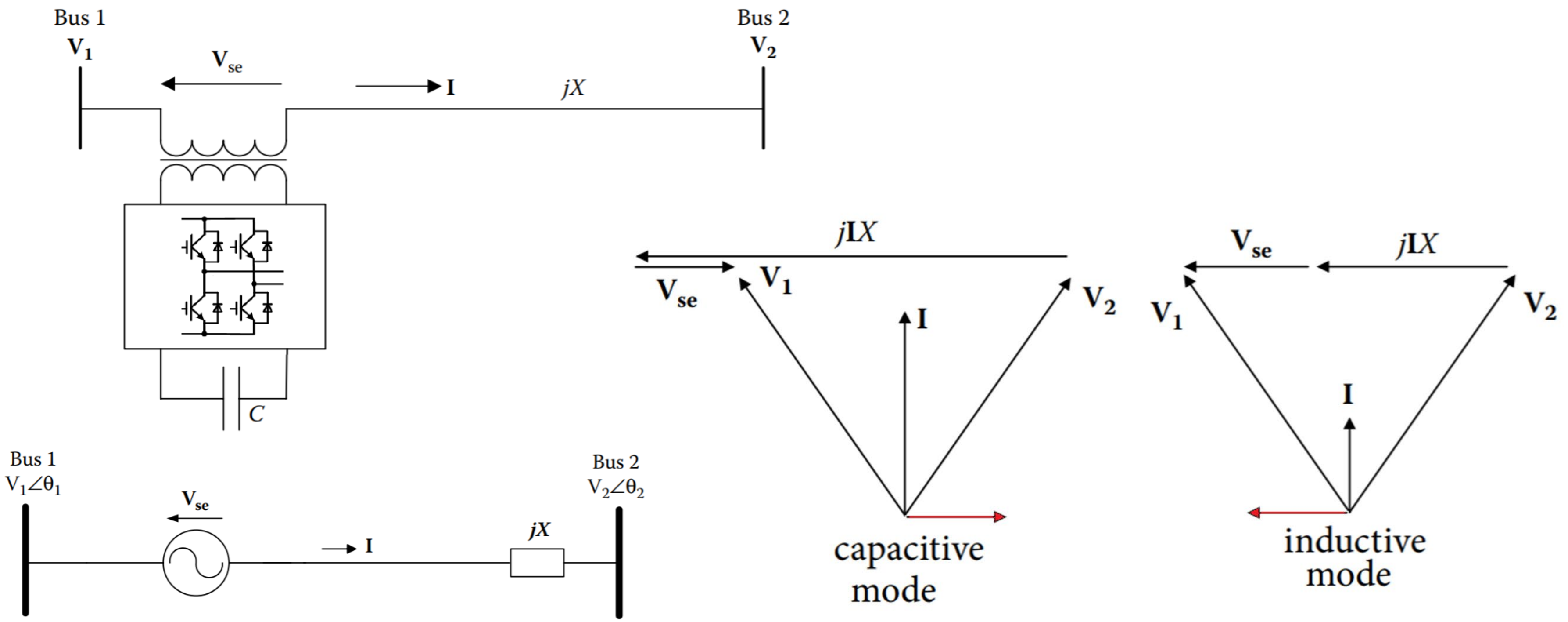
- Static Synchronous Series Compensator (SSSC)
- What is SMART VALVE?
- SMART VALVE Mode of Operations
- Control Methods With a Communication System
- Control Methods Without a Communication System
- How can SSSC be modeled?
- SMART Wire provided Model for SV

SSSC & SMART VALVE

- Static Synchronous Series Compensator (SSSC)
- A FACTS device
- Operates without an energy source as Reactive Power with output voltage
- Controls the electrical power flow by increasing or decreasing the overall reactive voltage drop across the installed transmission line
- Can provide either capacitive or inductive injected voltage compensation
- **SMART VALVE is an SSSC**

SSSC

- If SSSC injected ac voltage lags the line current by 90° a capacitive series voltage compensation is obtained
- If SSSC injected ac voltage leads the line current by 90° an inductive series voltage compensation is obtained



Control Methods With a Communication System

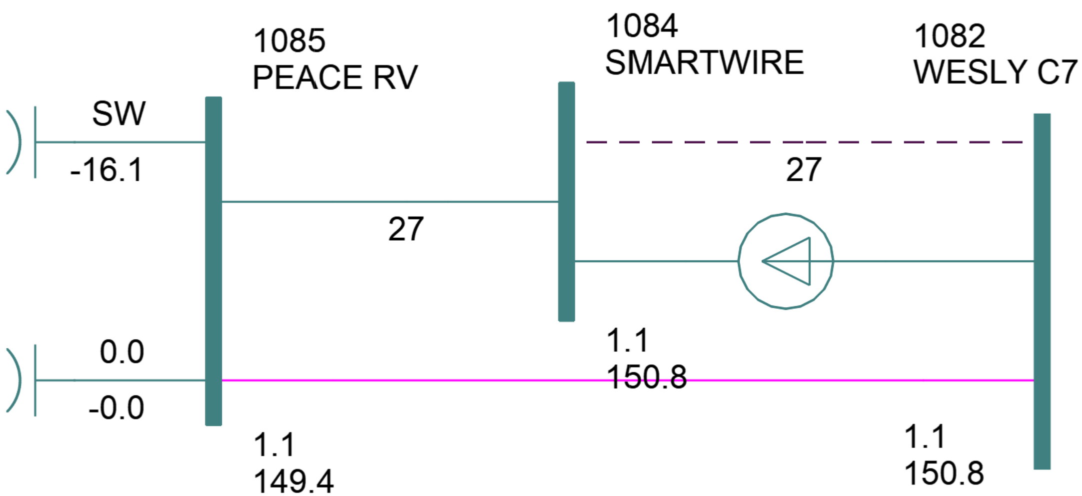
- **Injection at a fixed voltage –**
  - Set to output a fixed voltage injection that is either capacitive or inductive. In this control method
  - Injected reactance will vary as the line current changes
- **Injection at a fixed reactance –**
  - Set to output a fixed reactance that is either capacitive or inductive
  - Injected voltage will vary as the line current changes to keep the reactance at a set value
- **Current Control**
  - Regulates the magnitude of the current through the facility to stay above or below a given level. Future capability will enable to set to a given level

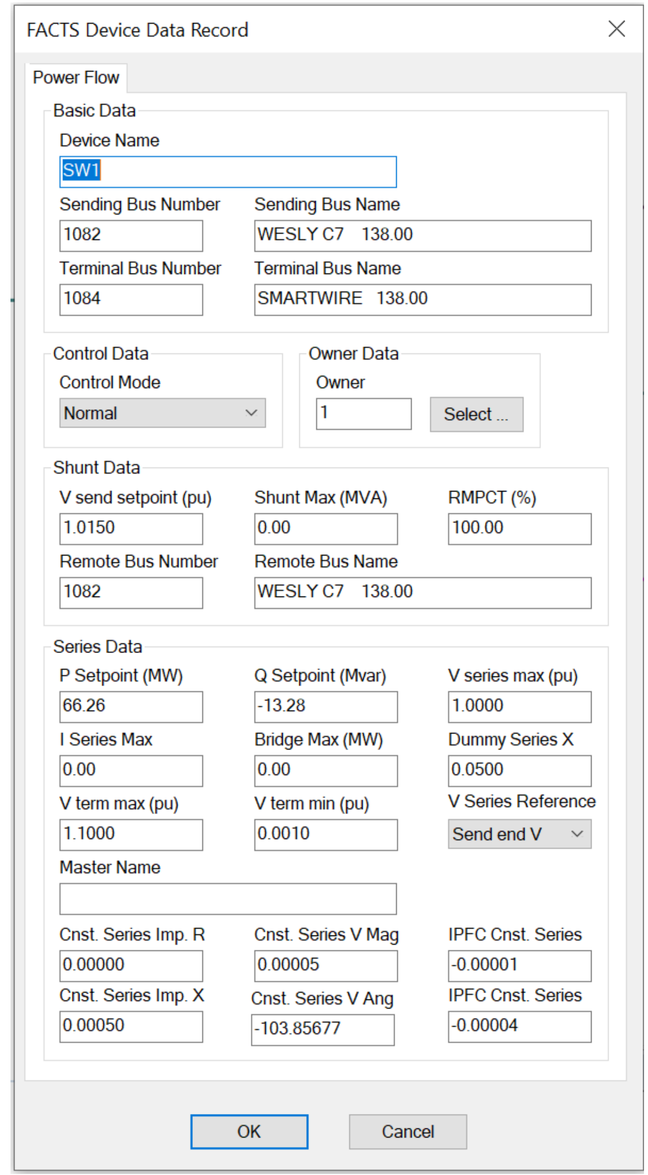
Control Methods Without a Communication System

- Continuously delivers a pre-programmed default level of reactance or voltage

How SSSC can be modeled?

- Using Fact Devices for load flow in general:

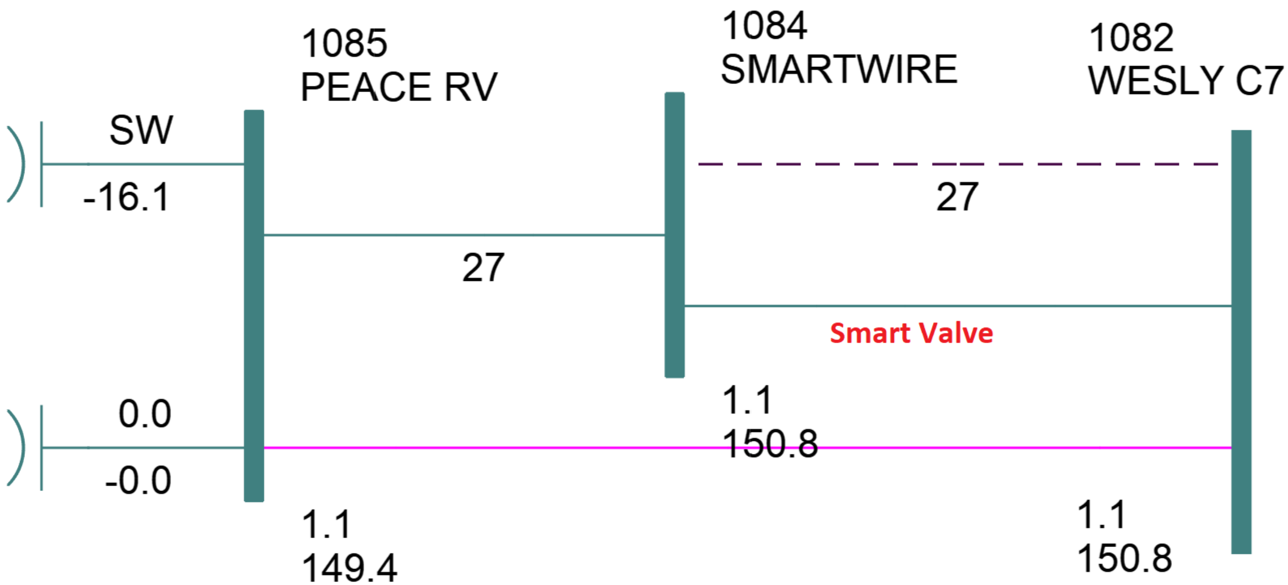




- Dynamics FACTS model for this device has not been tested and verified by WECC MVS

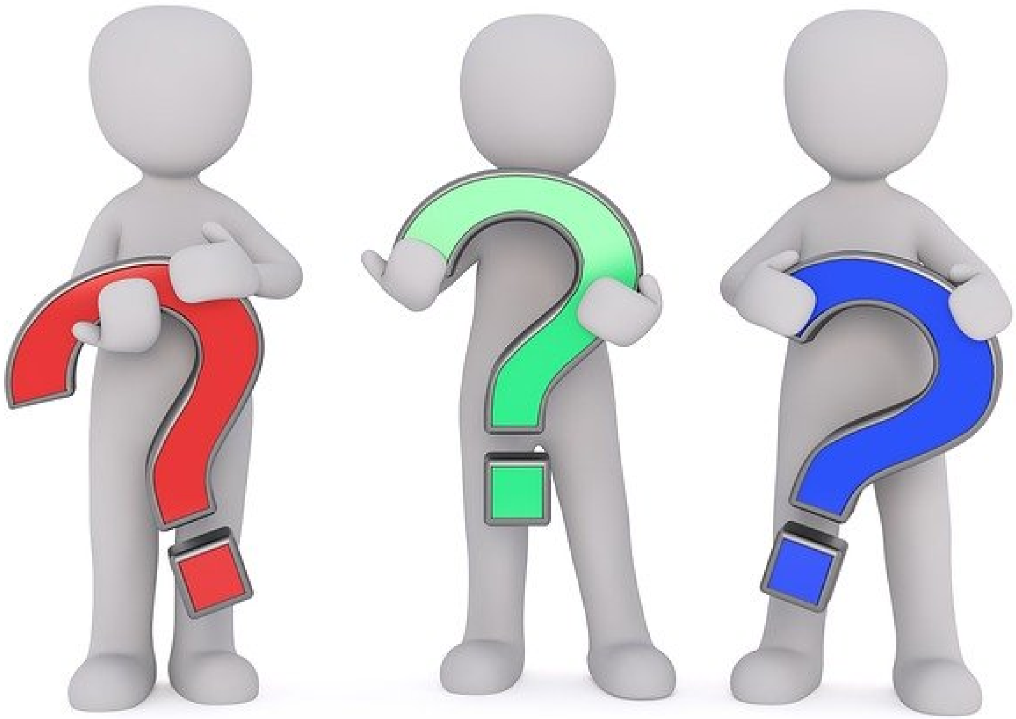
Smart Wire provided Model for SV

- Smart Wire suggests to model it as a constant reactance line and update reactance when control setting is changed



- Smart Wire suggest to use GRANIT branch device model to make bypass operation under overcurrent in dynamics simulation

Questions and discussion



Energy Storage Resources

Public

Topics

- Types of Energy Storages and power system studies model for:
  - Flywheel Energy Storage (FES) Systems
  - Compressed Air Energy Storage (CAES) System
  - Pumped Hydro Energy Storage (PHES)
  - Battery Energy Storage (BES) Systems

Type of Energy Storages in Power Systems

Battery

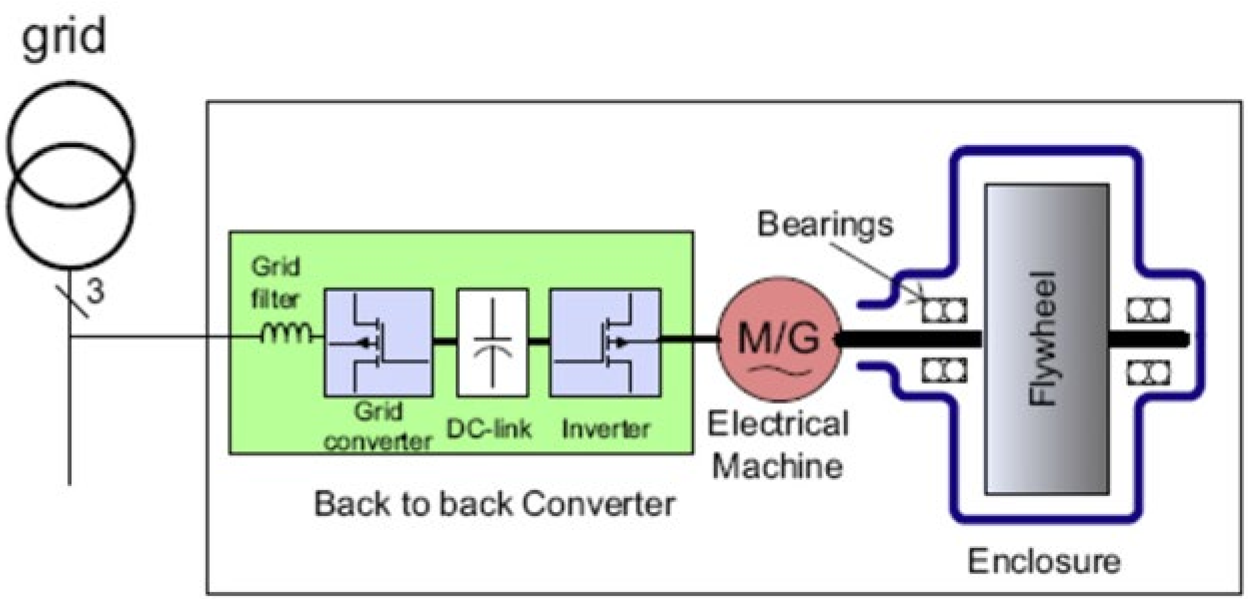
Pumped Hydro

Flywheel

Compressed Air

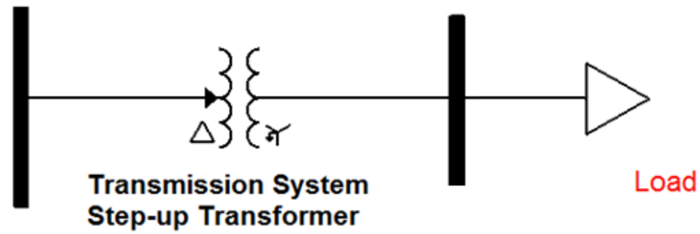
Flywheel Energy Storage (FES) Systems

- Balance the supply and demand
- Bidirectional converter can be DC – AC , AC – AC or AC – DC – AC

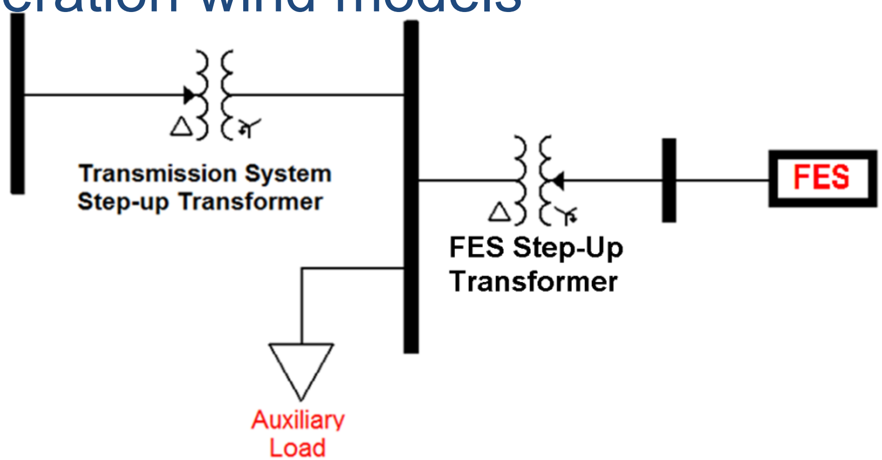


Electrical Models of Energy Storages: FES Model

- Charging mode

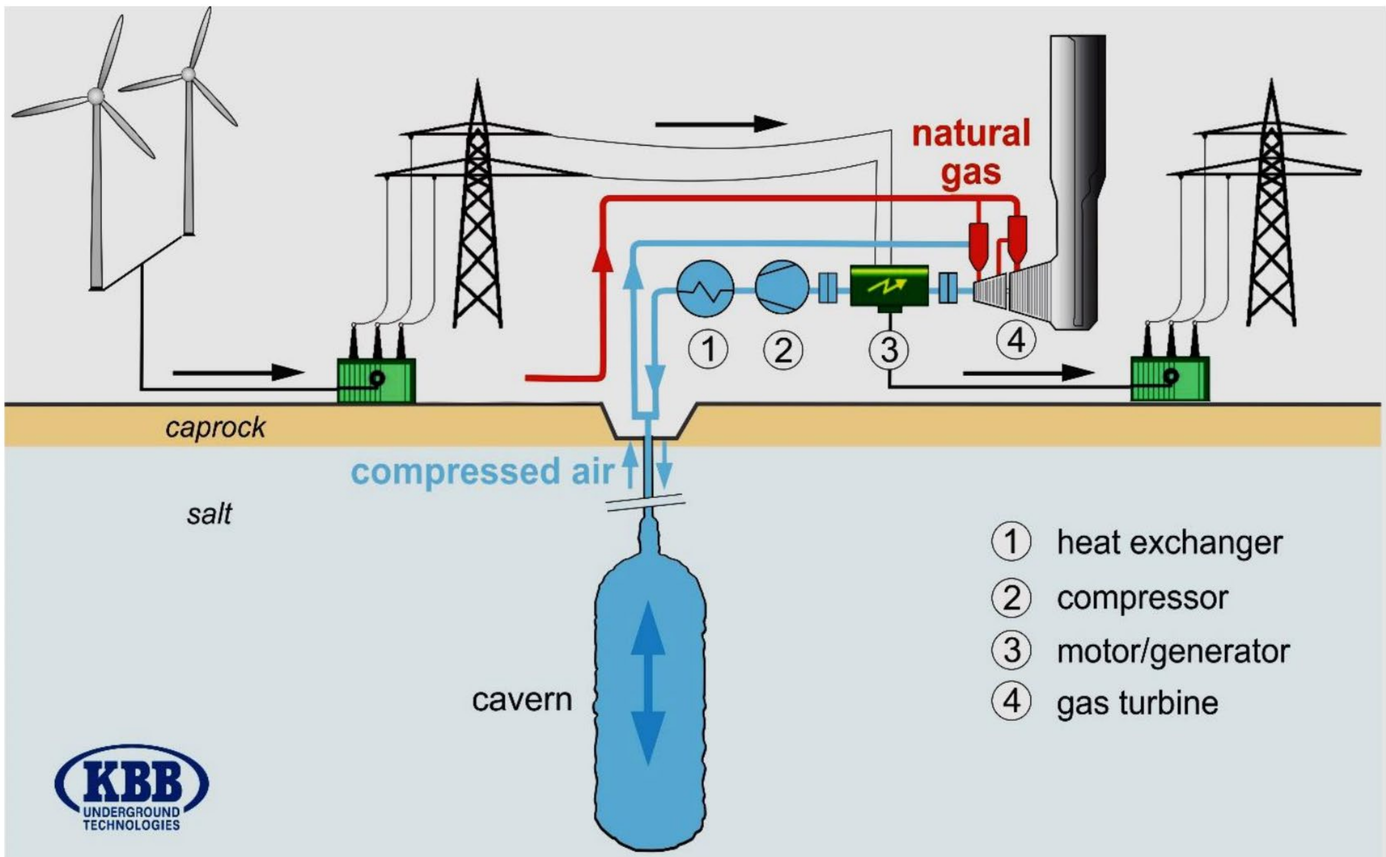


- Discharging Mode
  - Load Flow: Wind machine in control mode 1
  - In Dynamics: Second generation wind models
    - REGC, REEC, REPC



Compressed Air Energy Storage (CAES) System

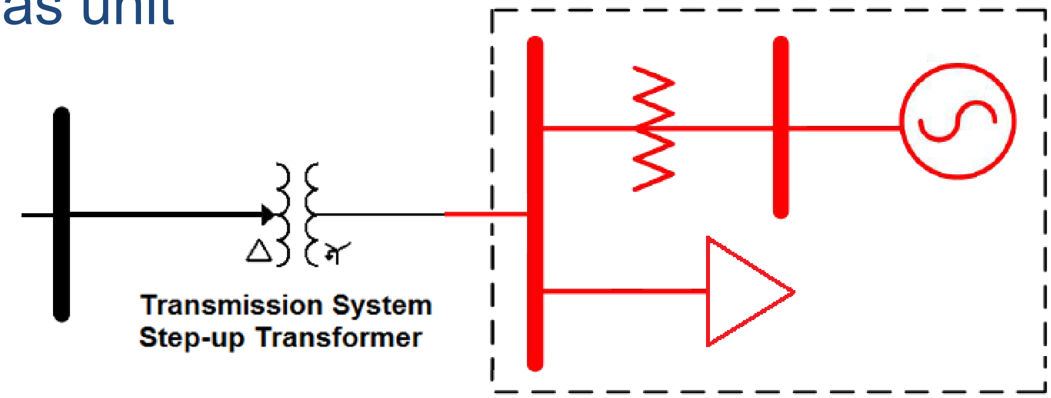
- CAES requires the combustion of fossil fuel to recover the stored energy
- CAES is not a pure electricity storage technology, it is hybrid
- One third of energy comes from fossil fuel mostly from natural gas



Electrical Models of Energy Storages: CAES Model

– Charging Mode and Discharging Mode can be modeled in one form as Gas units with a static load for compressor

– Technically it is a gas unit



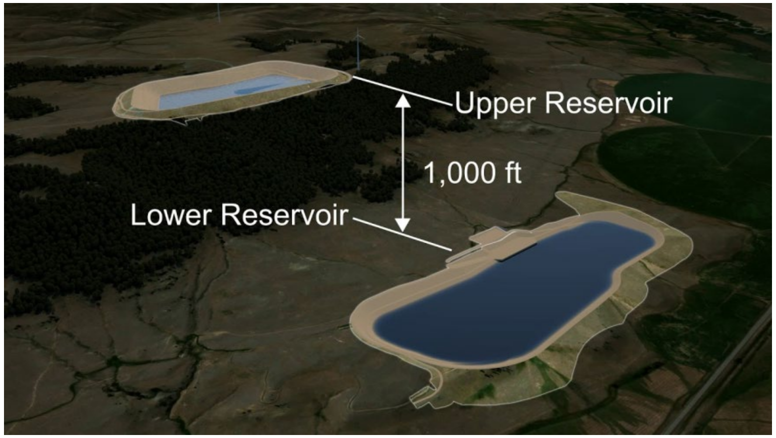
– Load Flow: Synchronous machine with control mode 0

– Dynamics:

- Generator: GENROU, GENTPG
- Exciter and Governor will be generic WECC approved models for GAS units

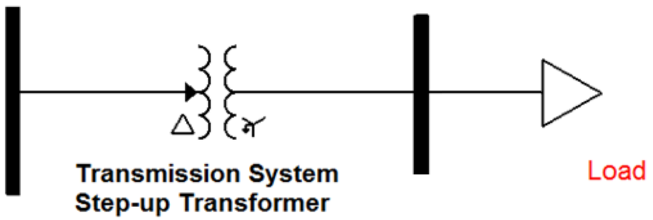
Pumped Hydro Energy Storage (PHES)

- PHES pumps water from a lower elevation reservoir to a higher elevation reservoir

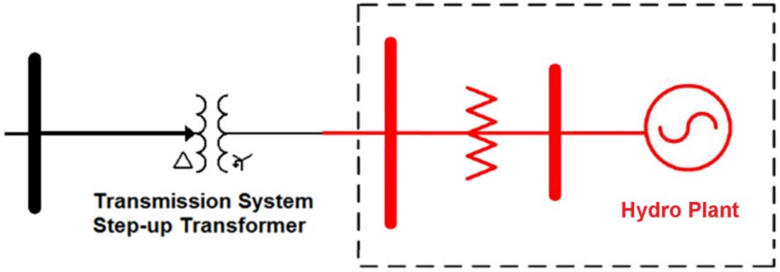


Electrical Models of Energy Storages: PHES Model

– In charging mode



– In discharging mode



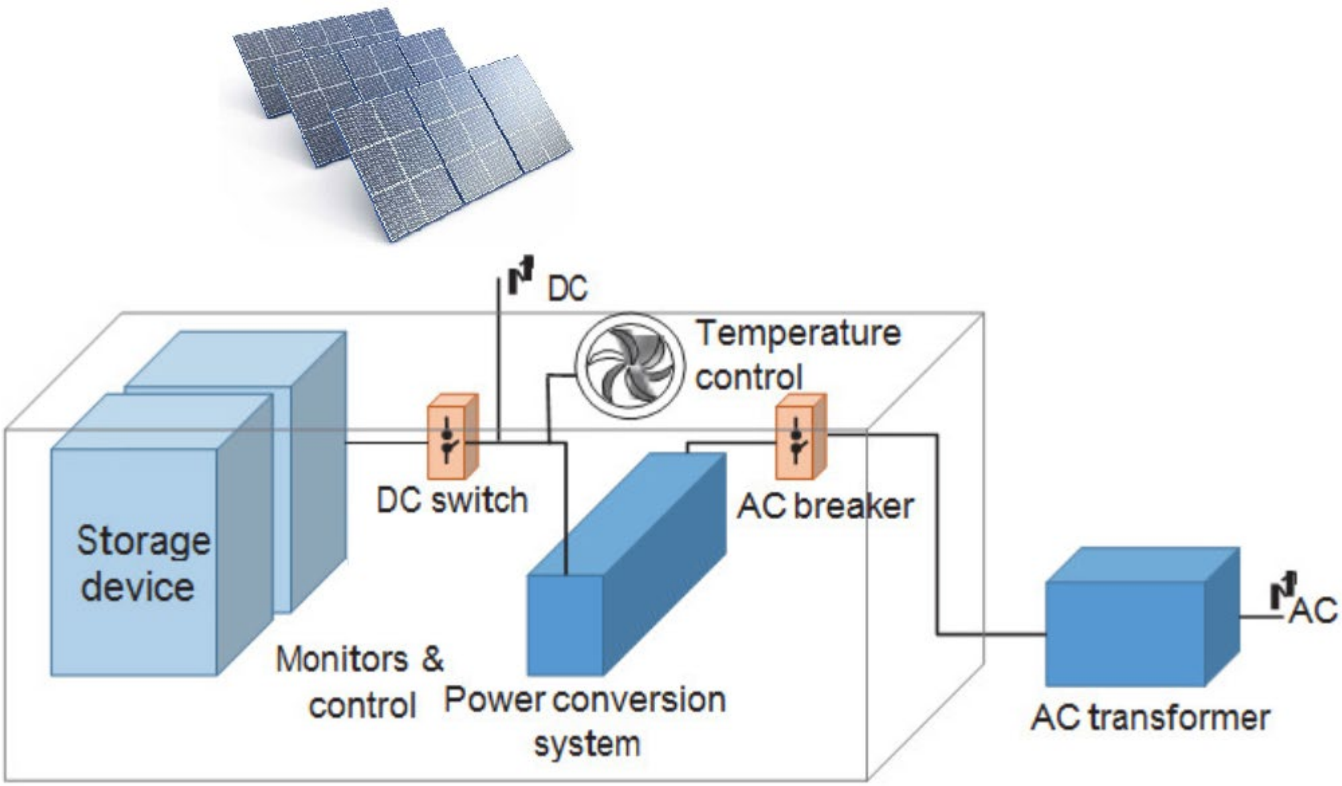
– Load Flow: Synchronous machine with control mode 0

– Dynamics:

- Generator: GENROU, GENTPG
- Exciter and Governor will be generic WECC approved models for a Hydro plant

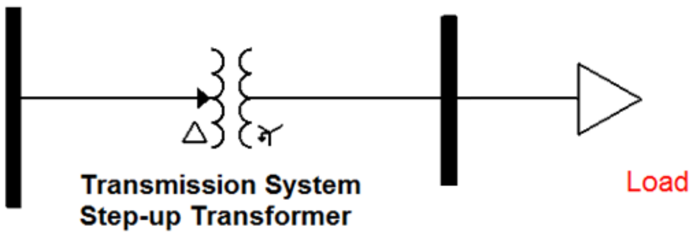
Battery Energy Storages

- Rechargeable battery systems
  - **store energy from solar arrays or the electric grid** and provide that energy to grid

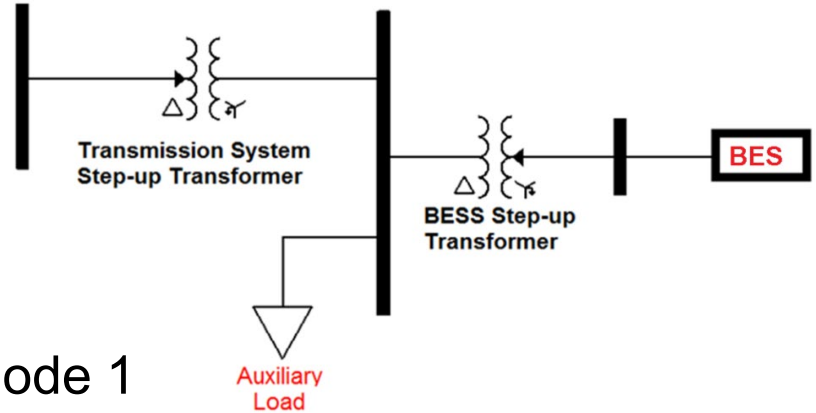


Electrical Models of Energy Storages: BES Model

– Charging mode

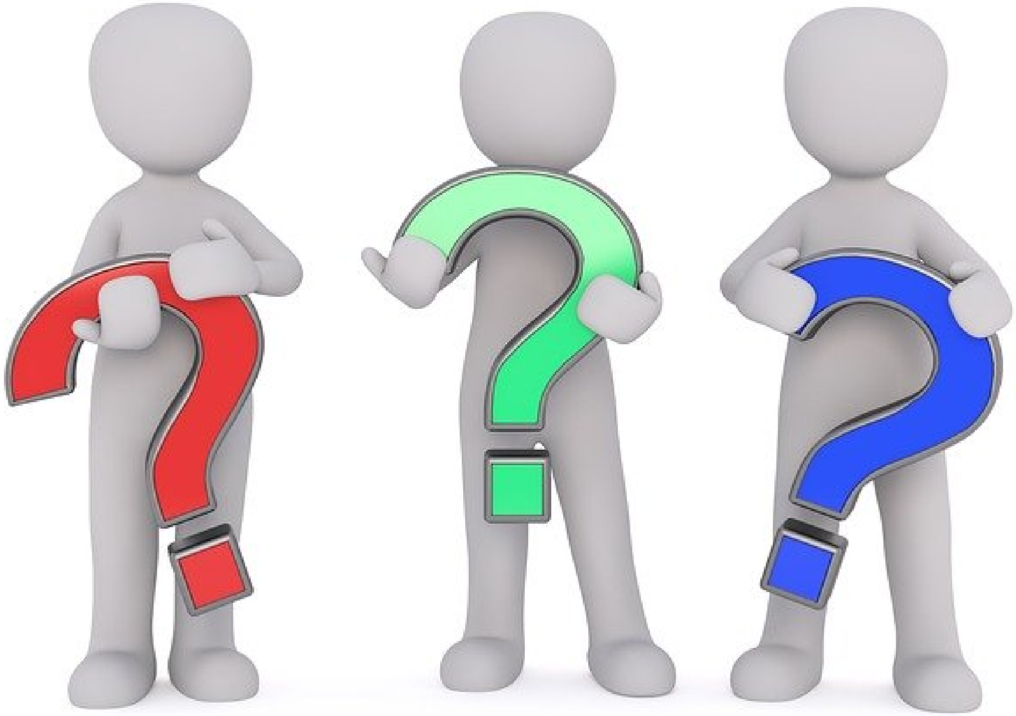


– Discharging Mode



– Load Flow:
  - Wind machine in control mode 1
– In Dynamics: Second generation wind models
  - REGC, REEC, REPC

Questions and discussion



Distributed Energy Resources

Topics

- Why and how we Model DERs in AIES
- Types of DERs: Types by Participation
- Observability
- Type of DERs by Technologies
- DER Technical Requirements
- Distribution System
- AESO Modelling requirements: ID #2010-001R
- Typical DER Model in AIES
- DER Model in AIES: LF Modelling Approach
- DER Model in AIES: Dynamics Modelling Approach
- Typical parameters: ID #2010-001R
- DER_A Model
- DER Feeder Modelling
- Questions and discussion

Why we Model DERs at AIES?

- To understand the impact of DERs on transmission system reliable operation and assess the need for transmission facility upgrade to reliably connect new DERs
- Distribution planning is not currently in AESO's scope
- Use simplified typical model for transmission system studies based on technical performance criteria

Types of DERs: Types by Participation

Market Participation Type			Characteristics	AESO Registration
Non-parallel operation			do not synchronize with the distribution system for more than 150 ms. (ie. Back up generation)	No Pool Asset ID No MPID No SCADA No settlement with AESO
Parallel operation	Non-exporting		load always exceed DER output and no power is exported to the grid	No Pool Asset ID No MPID No SCADA No settlement with AESO
	exporting	Small Micro-Generation	Renewable or low emission DER smaller than 150kW and only has cumulative metering. Designed to offset annual energy consumption	No Pool Asset ID No MPID No SCADA AESO settles with retailer
		Large Micro-generation	Renewable or low emission DER > 150 kV or =< 5 MW site equipped with interval metering. Designed to offset annual energy consumption	Pool Asset ID MPID No SCADA AESO settles with retailer
		DG	any energy source and any size Including Small Scale Generation and Community Generation	Pool Asset ID MPID SCADA if > 5 MW Must offer if > 5 MW AESO settles directly with the GFO

Observability

- At AESO Level:
  - Revenue meters
    - 15-minutes intervals on a monthly settlement basis.
    - Asset ID and Measurement Point ID
  - SCADA in 502.8 (Currently no specific requirement of "telemetry" function set for DERs smaller than 5 MW)
    - Real-time
    - Required for non-zero merit-order

Type of DERs by Technologies

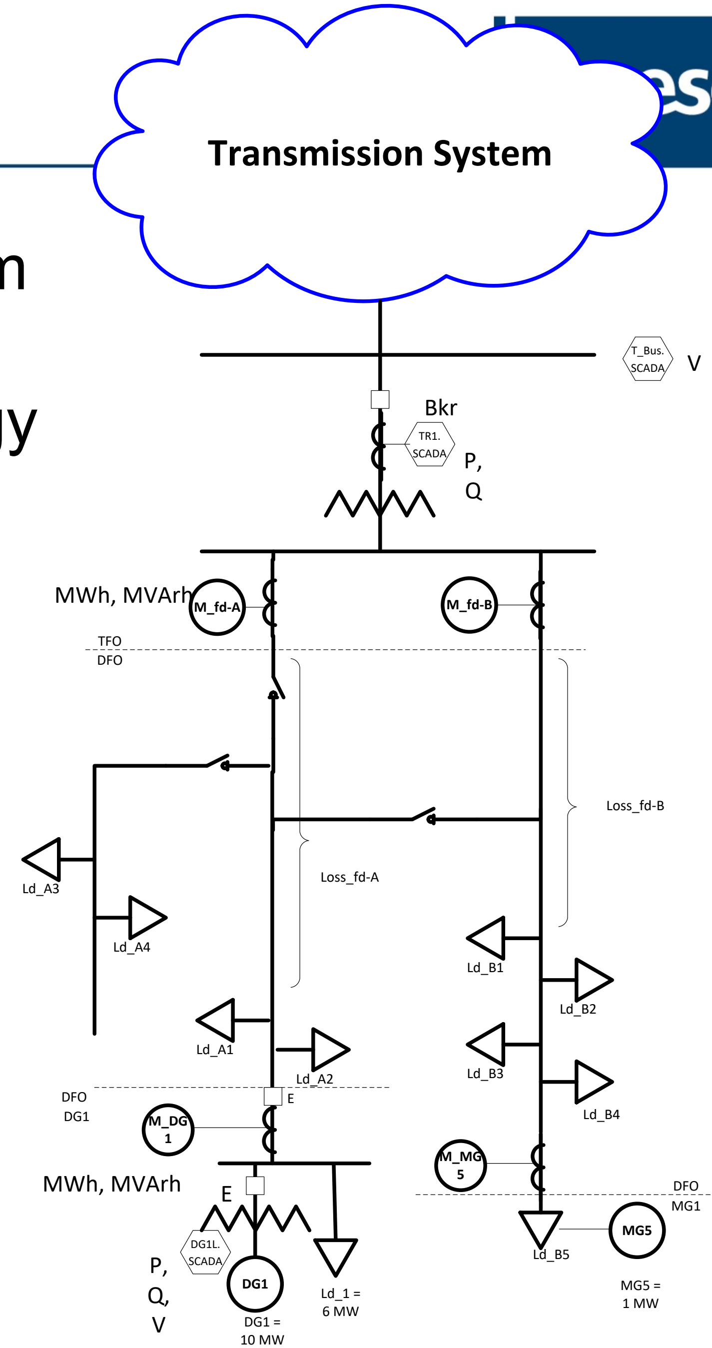
- **Combustion reciprocating engines**
  - Synchronous, light inertia, brushless excitation
- **Small gas turbines**
  - Synchronous, medium inertia, brushless excitation
- **Co-gen Steam Turbine**
  - Typically, larger units, Synchronous, medium inertia
- **Wind turbines**
  - **Asynchronous**, conversion depending on vintage, new ones are DFIGs or Second generations, full converter. Ride-through characteristics
- **PV Solar**
  - Full converter, **Synchronous**. Ride-through characteristics
- **Battery Storage**
  - full converter, **Synchronous**. Ride-through characteristics

DER Technical Requirements

- "CSA Standard C22.2 107.1 – Power Conversion Equipment"
- UL1741 Supplement A (Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources)
- Among the technical requirements, the following are pertinent to transmission system studies:
  - DER VAR control
    - **PF control**
    - Voltage control [Generally not accepted by DFOs]
  - Active power control
  - Anti-Islanding
    - Passive
    - **Transfer Trips [for EMS]**
  - **Fault Ride-through**

Distribution System

- Simplified Conceptual Diagram of an Electric Distribution System with Distributed Energy Resources



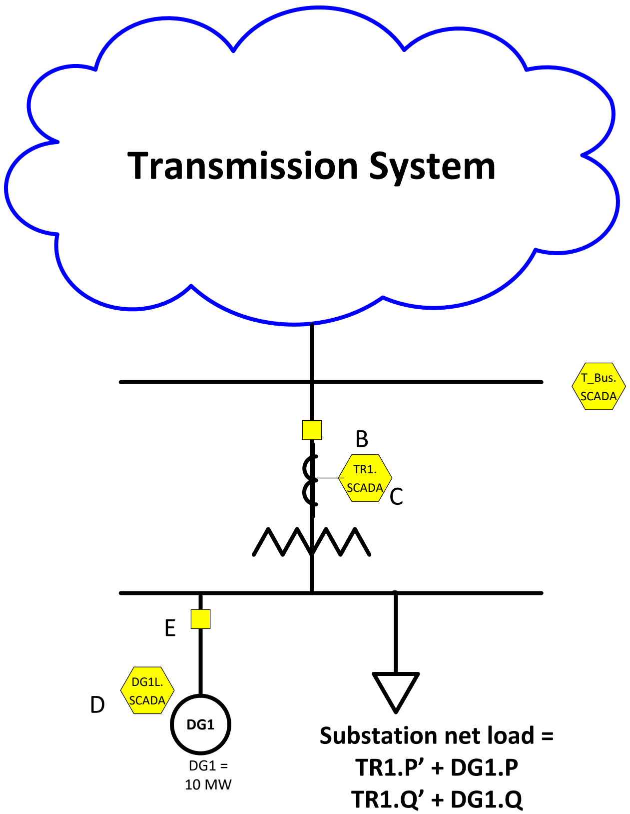
Distribution System

Substation net load includes:

- All distribution loads including load at DG site

Non-observable quantities:

- Gross substation load
- Microgeneration outputs
- Feeder losses



AESO Modelling requirements: ID #2010-001R

- Appendix 1, section 4.5.5 Distributed Energy Resources has been amended
- Appendix 2, Distributed Energy Resource Modelling Guideline has been added
  - Contains guideline on using generic models with typical parameters for DERs

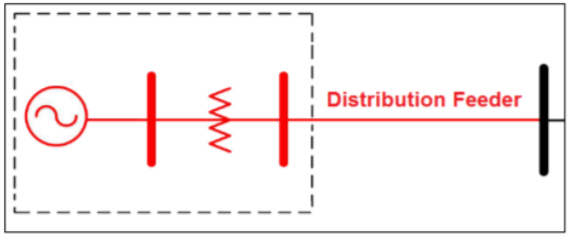


Figure 1 Power Flow Model of a Distributed Energy Resources Connection with One or More Identical Generating Units

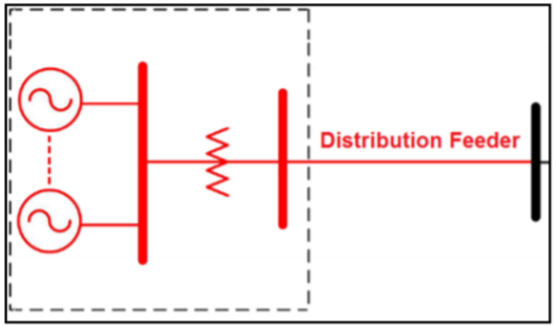
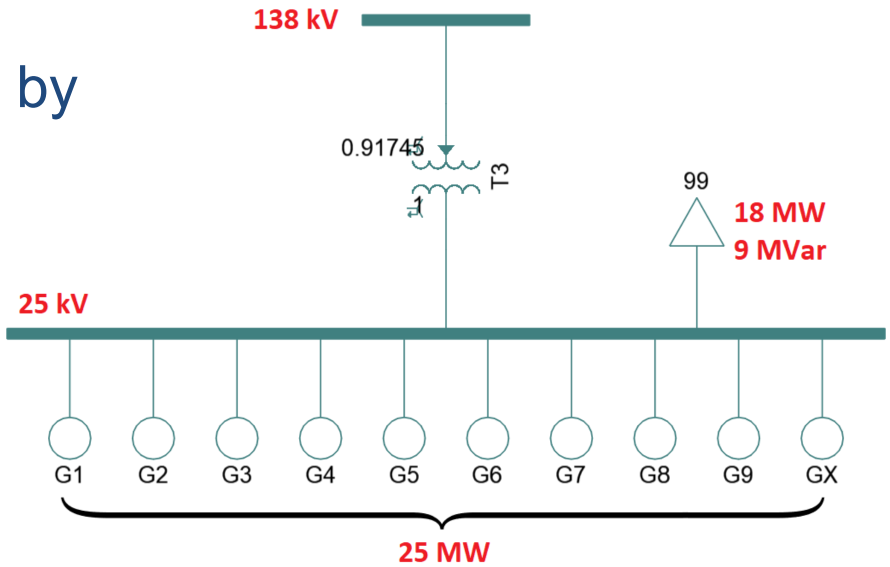
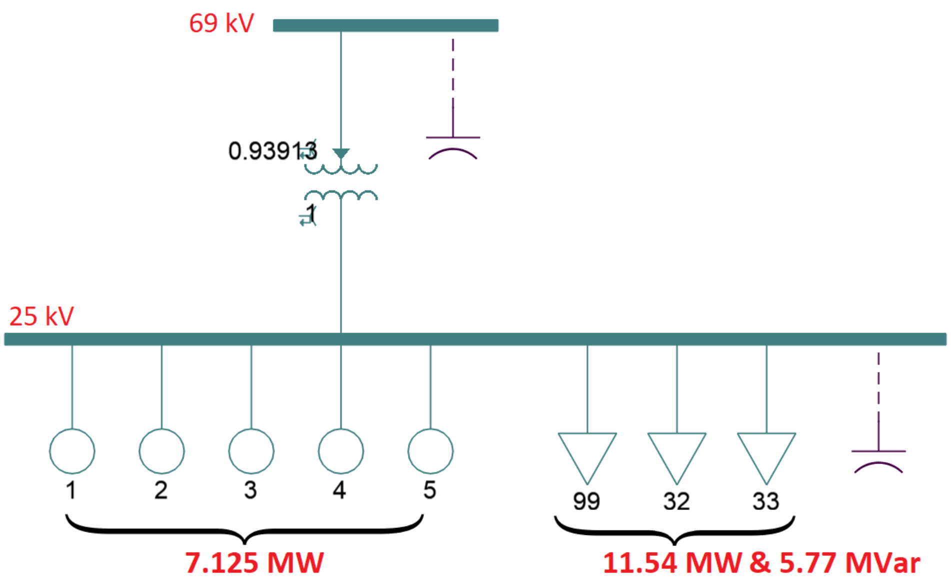


Figure 2 Power Flow Model of a Distributed Energy Resources Connection for Non-identical Generating Units

A DER Model in AIES

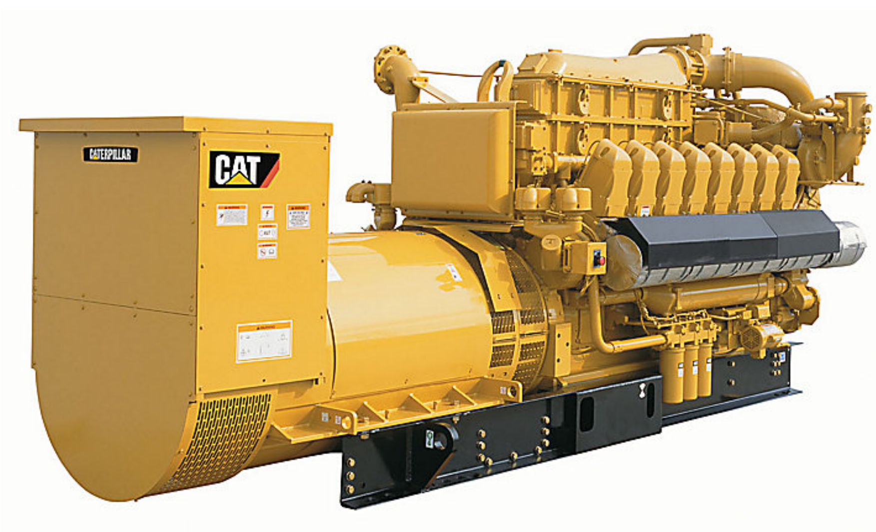
- Two examples
  1) PV
  2) Reciprocal rotating engine fed by Natural Gas

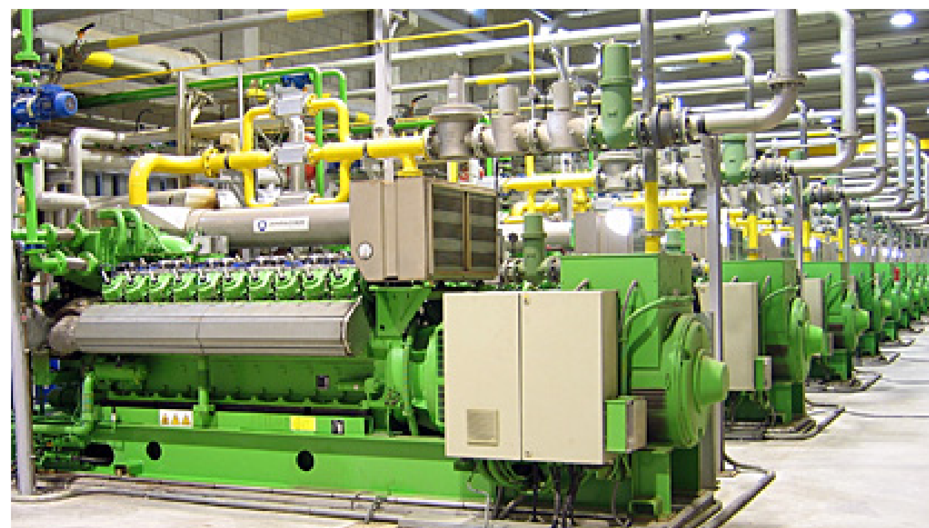




A DER Model in AIES

- Reciprocal rotating engines are:
  - Synchronous Generator
  - Operating in constant PF control Mode



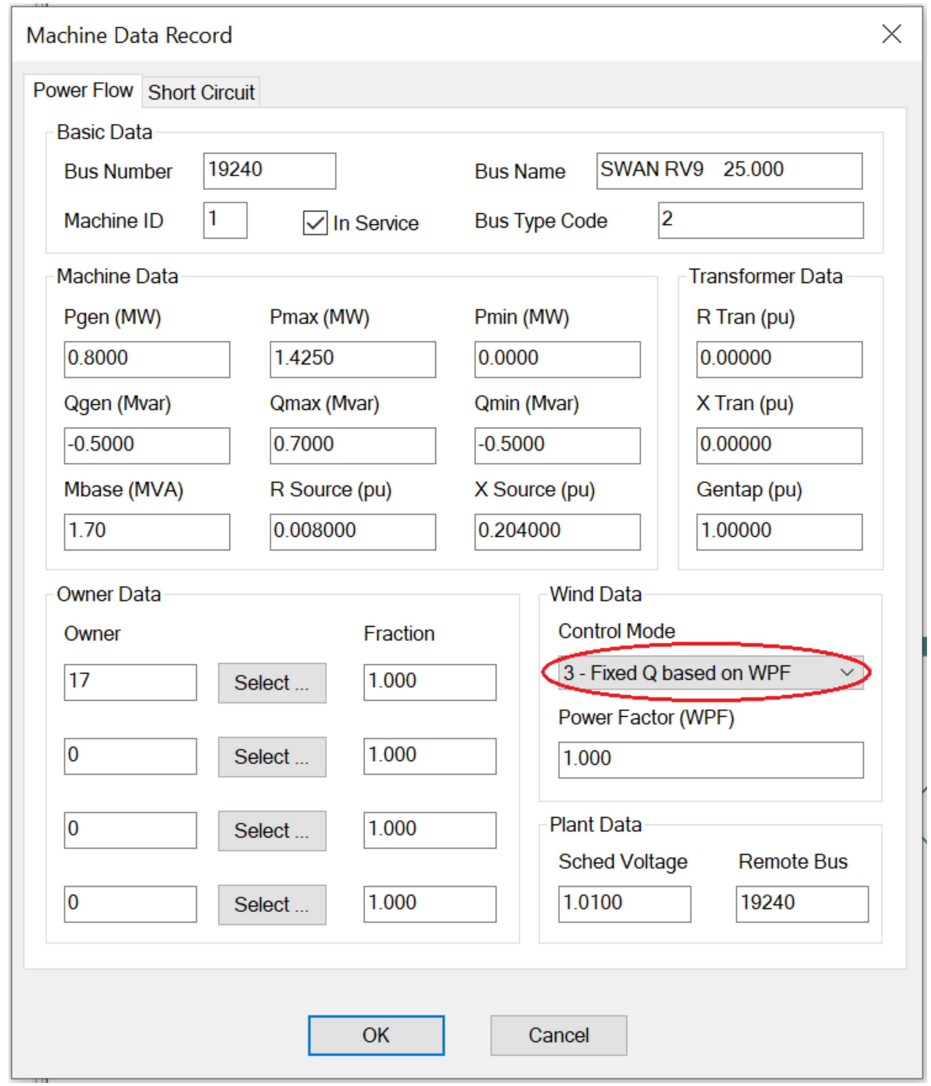


A DER Model in AIES: LF Modelling Approach

- How can the DERs constant PF control mode be modeled?
  - Approach 1:
    - Calculate Qgen based on Pgen and PF
    - In the model put

    Qgen = Qmax = Qmin
  - Approach 2:
    - Use Control Mode

    3 – Fixed Q based on WPF



A DER Model in AIES: LF Modelling Approach

- PV solar, Wind, Energy storage DERs which are inverter-based system are modeled as wind
- Synchronous Machin base DERS:
  - Approach 1 is not the preferred approach. Because every time when the dispatch value is changed Qgen should be calculation and model parameters should be updated
  - In approach 2 there is no need to update model with every new dispatch however, for the purpose of dynamics simulation, the control mode of these units should be changed to Control Mode 0
  - This is done by an IDV added to the GNET IDV

A DER Model in AIES: Dynamics Model

- PV solar, Wind, Energy storage DERs can be modeled with second generation wind models (i.e., regc_a, reec_b, repc_a, lhvrt, lhfrt, or pvd models)
- However, utility scale DERs are recommended to be modeled with **DER_A** model
- Synchronous Machine DERs operating in constant PF control mode are modeled with conventional synchronous machine models with
  - No Exciter model: Because appropriate exciter model for constant PF control mode operation has not been developed by PTI
  - No Governor Model: these units don't have Primary or Secondary frequency response. They have only inertia response

Typical parameters: ID #2010-001R

- Typical parameters for Reciprocating Engine Generators:

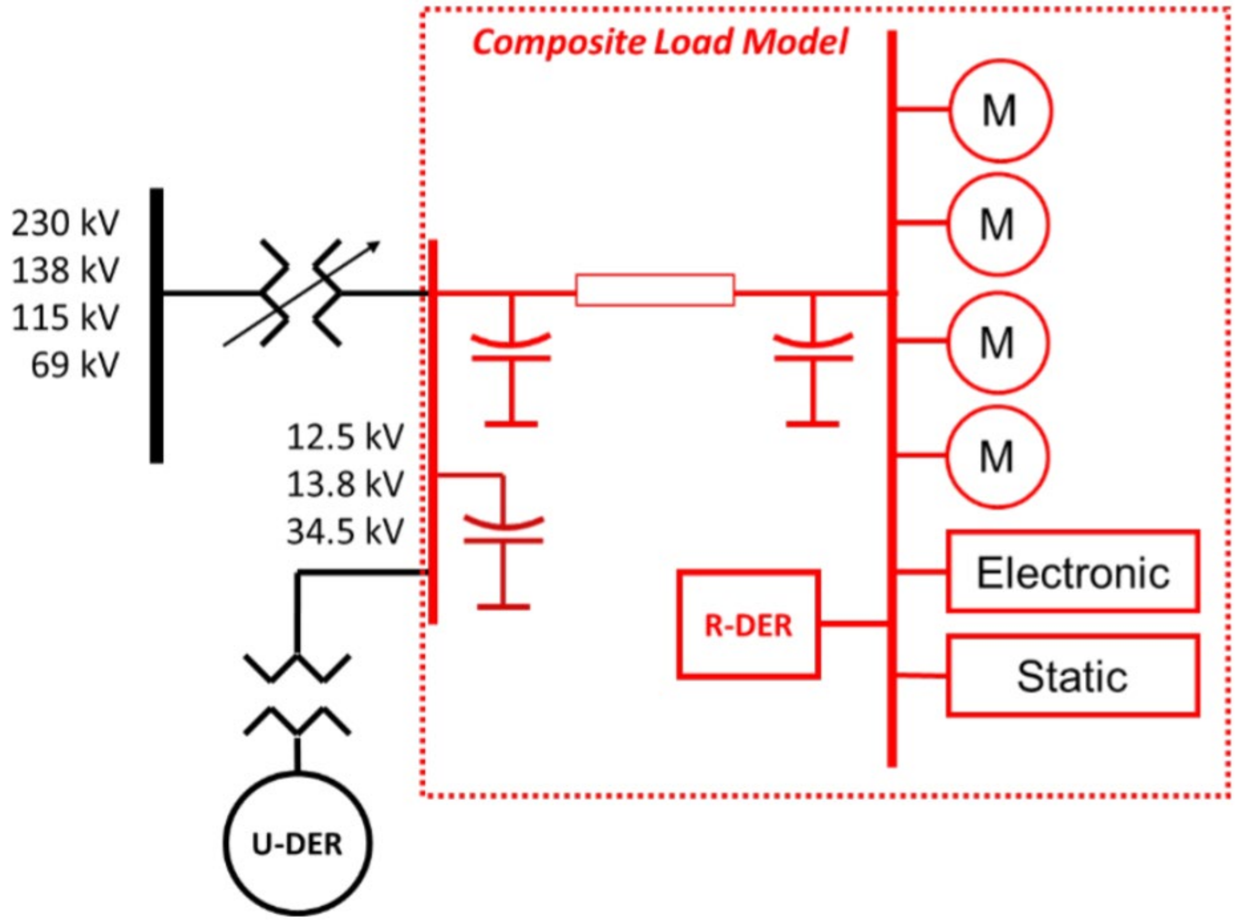
	GENTPJ Model					
	High Voltage reciprocating	Medium Voltage reciprocating	Low Voltage reciprocating	Steam Turbine	Small Hydro	Gas Turbine
Generator Voltage Range	7.2-13.8	4.16	380-690	Any	Any	Any
T'_{d0}	4.478	2.967	2.214	6	6	6.5
T'_{q0}		0.313		1	0	1
T''_{q0}		0.2		0.035	0.0650	0.03
H	1.2	1.2	1.2	3	1.7	4.2
D	0	0	0	0	0	0
X_d	2.242	2.227	2.647	1.8	1.45	1.6
X_q	1.62	1.217	1.71	1.7	1.05	1.5
X'_d	0.188	0.284	0.167	0.2	0.47	0.2
X'_q		1.217		0.4	1.05	0.3
X''_d	0.139	0.179	0.123	0.18	0.33	0.13
X''_q	0.261	0.197	0.262	0.18	0.33	0.13
X_l	0.101	0.13	0.1	0.12	0.28	0.1
S(1.0)	0.2	0.2	0.2	0.2	0.2	0.1
S(1.2)	0.6	0.6	0.6	0.6	0.6	0.4
K_{is}	0	0	0	0	0	0
K J=K*VA		0.029	0.027			

DER_A Model

- Simplified version of the second generation generic renewable energy system models
- DER_A uses a reduced set of parameters meant to represent the aggregation of a large number of inverter-interfaced DERs
- More detailed and flexible than PVD1 model
- It includes additional modeling flexibility for more advanced and representative capabilities introduced in IEEE Std. 1547-2018
- The DER_A model can be used to represent U-DERs and can also be used to represent R-DERs as either a standalone DER dynamic model or as part of the CLM

DER_A Model

- Composite Load Model Representation with U-DER



DER_A Model

- The DER_A model includes the following features:
  - Constant power factor and constant reactive power control modes
  - Active power-frequency control with droop and asymmetric deadband
  - Voltage control with proportional control and asymmetric deadband
  - Representation of a fraction of resources tripping or entering momentary cessation at low and high voltage, including a four-point piece-wise linear gain

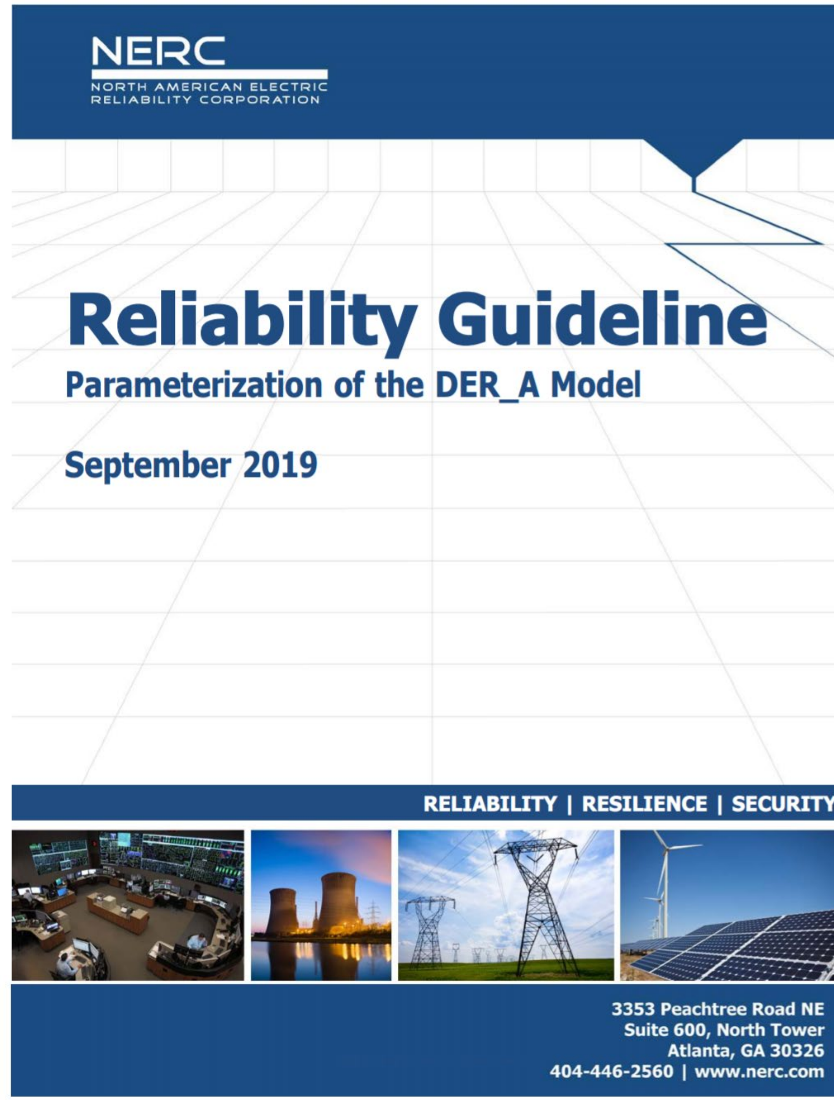
DER_A Model

- The DER_A model includes the following features:
  - Representation of a fraction of resources that restore output following a low or high voltage or frequency condition
  - Active power ramp rate limits during return to service after trip or enter service following a fault or during frequency response
  - Active-reactive current priority options
  - The capability to represent generating or energy storage resources

DER_A Model

- It has been provided in PSSE/V34.6 DERAU1
- Links and reference in ID-2010-001R
- For more information, please refer to the NERC Reliability Guideline: "Parameterization of the DER_A Model" September 2019 at:

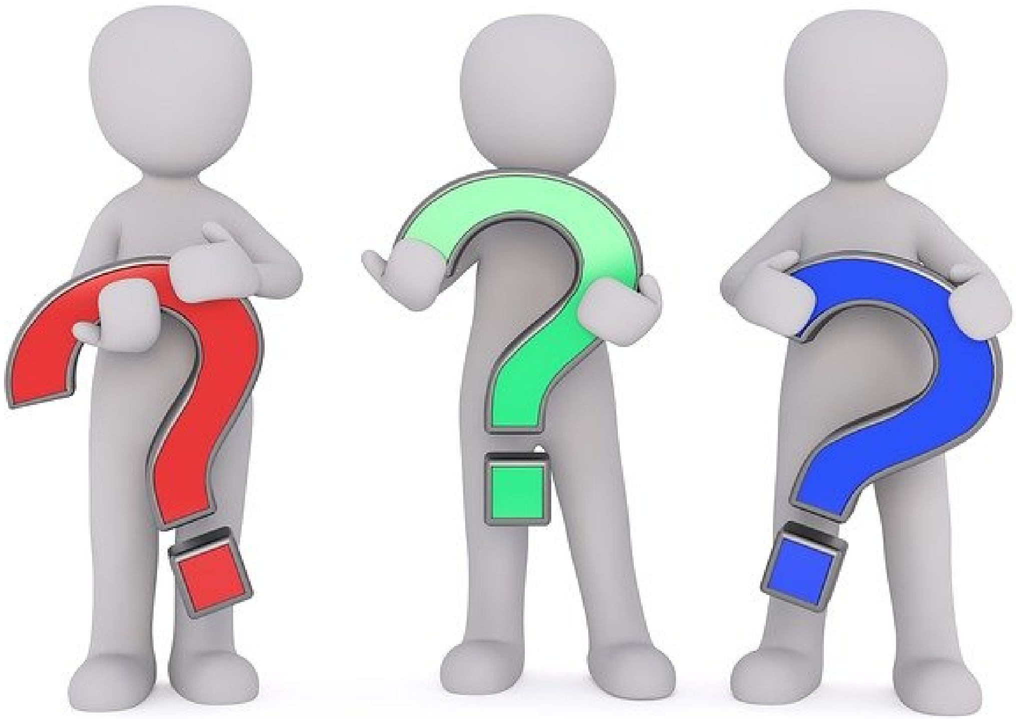
https://www.nerc.com/comm/PC_Reliability_Guidelines_DL/Reliability_Guideline_DER_A_Parameterization.pdf



DER Feeder Modelling

- The feeder impedance should be included for connection studies under the following conditions:
  - Short circuit studies with synchronous DER
  - Dedicated feeder for DER
  - DER operating at power factors lower than 0.95 leading
  - DER with local voltage control

Questions and discussion



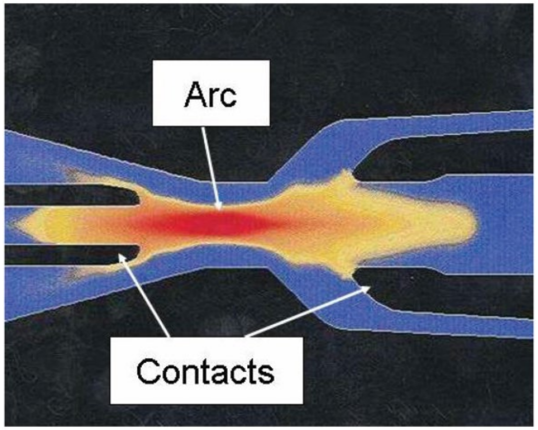
Transient Recovery Voltage (TRV) / Temporary Overvoltage (TOV)

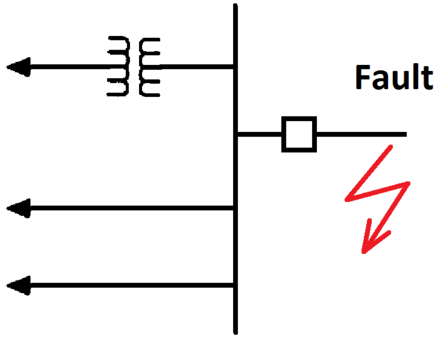
Topics

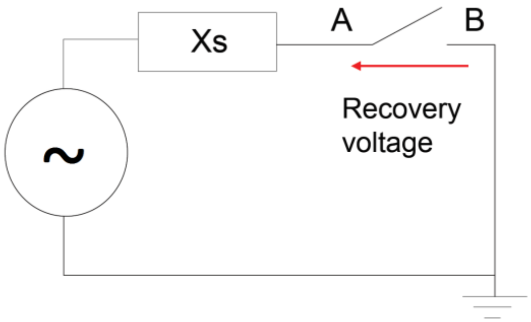
- TRV/RRRV
- TOV
- TRV/TOV Impacts on System
- TRV/TOV Issues in Transmission
- TRV/TOV Issues in Distribution by DER
- Future DER Modelling Data Requirements

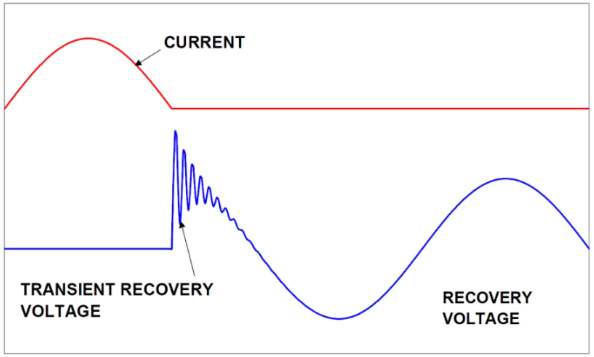
TRV/RRRV

- TRV is the voltage that builds up across a circuit breaker after the interruption of a (fault) current
- It consists of oscillations of lumped elements and of traveling waves
- It stresses the circuit breaker contacts
- The breaking operation is successful if the circuit breaker can withstand the TRV and the power frequency recovery voltage



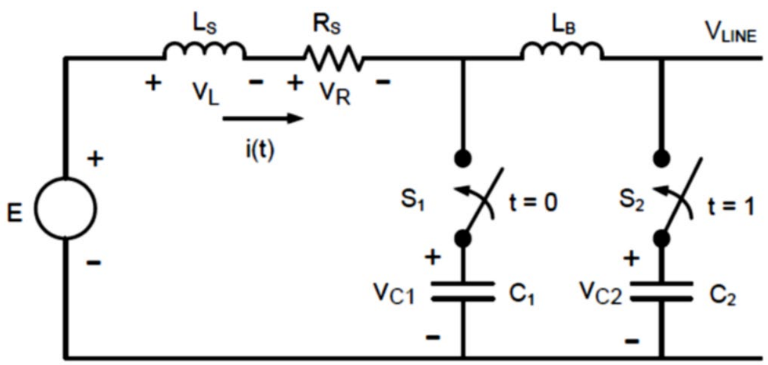


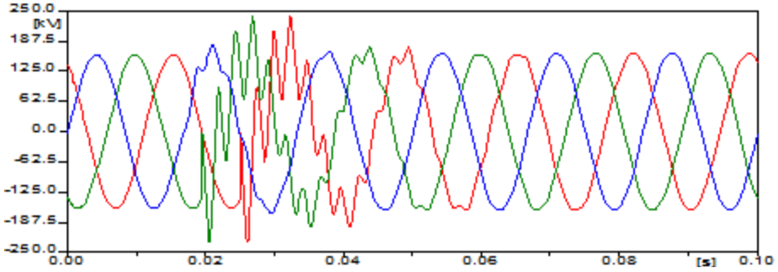




TOV

- Transient Overvoltage (TOV):
  - Any voltage over than the temporary operating limit is considered as TOV
  - TOVs may last from a few msec to a few seconds
  - Asymmetrical fault in ungrounded or non effectively grounded system
  - Any switching in the system causes TOVs
    - Cap bank switching, back-to-back oscillations with nearby capacitors or even capacitors banks one or two substation away
    - Transmission lines switching, including generator, loads and other components



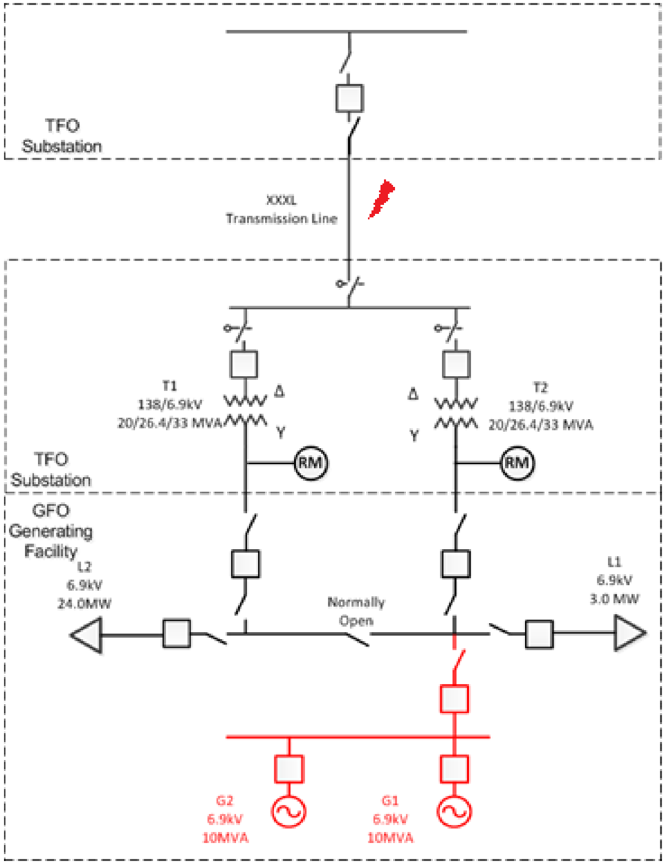


TRV/TOV Impacts on System

- A breaker failure due to excessive TRV:
  - Results in slower fault clearing
  - Eventually results in additional facilities (generation/load) tripping in the area
  - Cause system reliability issue
- TOV issue:
  - The voltage magnitude will be beyond equipment insulation specification and surge arrestors,
  - CT and PT attached on the line may get permanent damaged.

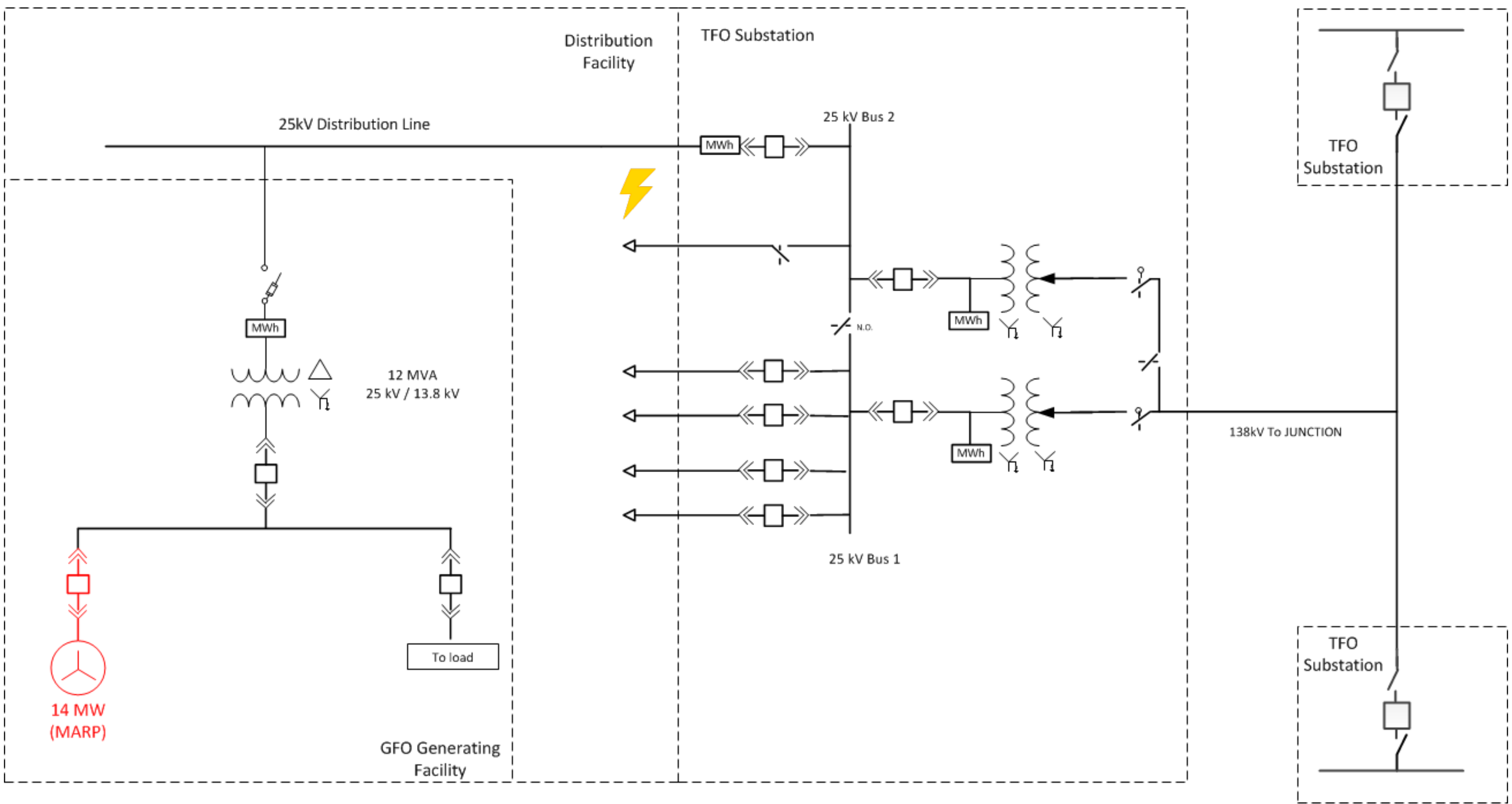
TRV/TOV Issues in Transmission

- Addition of an onsite generation to an existing load substation may cause both TRV and TOV
- Combination of an active source and ungrounded delta on HV side of transformers



TRV/TOV Issues in Distribution by DER

- A similar scenario may be seen on distribution facility when adding a DER with delta on HV of transformer
- Therefore, addition of a generation source in system that isn't effectively grounded may require additional study due to TRV/TOV issues
- Over 300+ ungrounded delta HS transformer in Alberta



Future DER Modelling Data Requirements

- The AESO is working on the DER modelling requirements to:
  - Fault current contribution from DERs can be calculated accurately
  - The risk of TOV/TRV violations on transmission, distribution can be addressed accordingly
    - There might be a EMTP type of simulations for IBRs for detail assessment

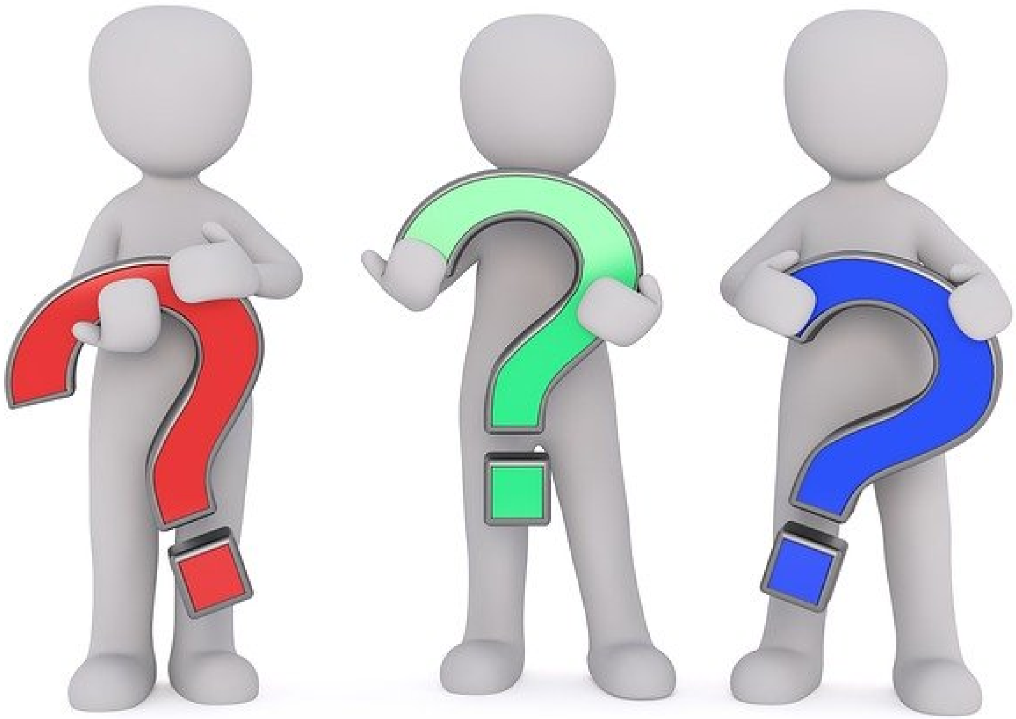
Future DER Modelling Data Requirements

- Up to date information of grounding (Resistance or Reactance) will be provided to the AESO by TFO/GFO and DFO
  - Sequence network topology (depending on generator grounding and transformer winding configuration)
  - Sequence impedance including positive/negative/zero sequence (depending on control algorithm if it is IBR)
  - Supplemental grounding device should be included (grounding transformer, grounding resistor or grounding reactors) in the sequence model.

Future DER Modelling Data Requirements

- Information can be either in
  - equivalent model or
  - breaker down of generator, GSU transformer and supplemental grounding device
- Other info that may impact study result:
  - voltage control mode and
  - installed capacity of the generator

Questions and discussion



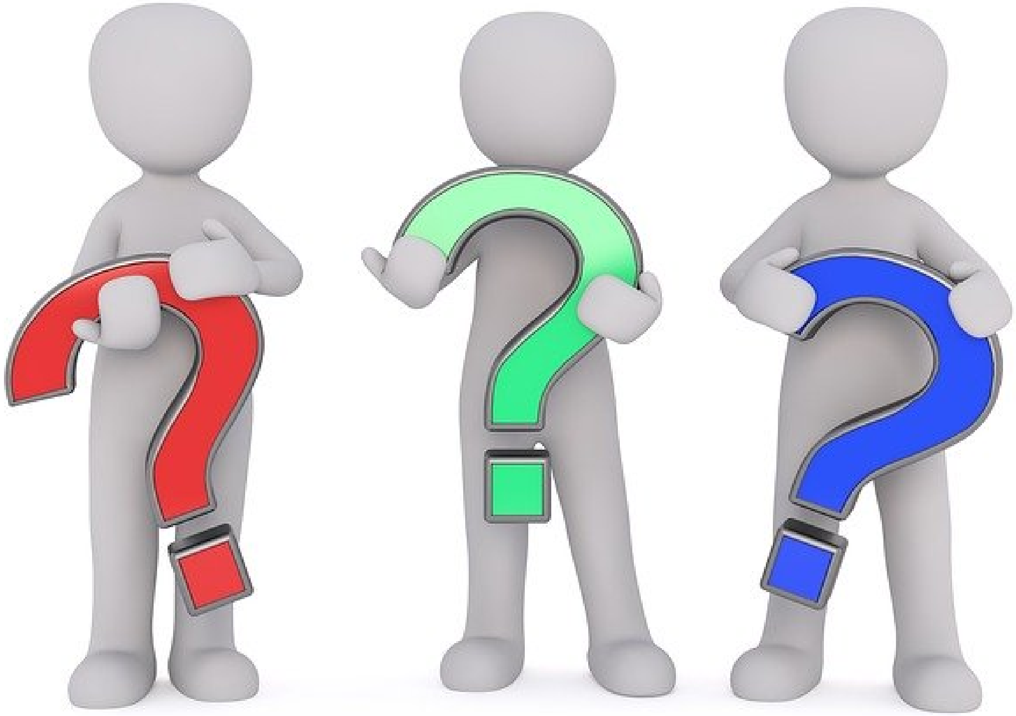
2021 Planning Base Cases Suite (PBCS)

Public

Overview of changes to 2021 PBCS

- Instruction on how to access the base cases data within the base case report pdf file
- Treatment of DER in power factor control mode
- Connection project inclusion criteria using legacy and updated ISO tariff section 3.7(6)
- Clarification on transformers with 6 MVA ratings: only transformers with both terminals at 100kV+ are required to have 6 ratings

Questions and discussion



For more information

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- Information Document: Facility Modelling Data and List of Electrical and Physical Parameters for Transmission System Model ID #2010-001R
  – Rules, Standards & Tariff ► ISO Rules ► Section 502.15 – Reporting Facility Modelling Data
- Base Cases: Process to request base cases
  – Grid ►Base Cases

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Thank you