BC HYDRO

T&D SYSTEM OPERATIONS

SYSTEM OPERATING ORDER 7T-13

G.M. SHRUM / PEACE CANYON 500 kV SYSTEM OPERATION

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1.0 GENERAL

This System Operating Order (SOO) describes the operation of the G.M. Shrum (GMS), Peace Canyon (PCN), McMahon Co-generation (MCM), Bear Mountain Wind Farm (BMW), Dokie Wind Farm (DKW), Quality Wind Farm (QTY), and Meikle Wind Farm (MKL) generating stations, and the 500 kV transmission system from GMS/PCN to the Lower Mainland.

This SOO documents System Operating Limits (SOL) and RAS Arming Requirements for the area interconnection in Section 5, Section 8, and supporting attachments. These limits are in effect to cover the worst-case operating conditions. Variations from these limits and arming conditions for specific operating conditions, on a case by case basis, will be provided through additional Operating Plans. These Operating Plans are engineered to support outages and short-term operating requirements, superseding as necessary requirements in this order.

RAS arming requirements also consider generation in the North Coast interconnection (see SOO 7T-30) arming generation shedding at Kemano (KMO), Forrest Kerr (FKR), McLymont (MCY), and Volcano (VOL) generating stations (refer to Section 5.2 of this order).

For TSA-PM implementation, the Peace area generation consists of:

GMS: There are 10 generators at GMS with a total capacity of 2820 MW (capability at .95 pf).

PCN: There are 4 generators at PCN with a total capacity of 700 MW (capability at .95 pf)

MCM: There are 2 generators at MCM with a total capacity of 110 MW. MCM is connected to GMS through the area 138 kV system.

BMW: There are 34 3-MW wind turbines at BMW with a total capacity of 104 MW. BMW is connected to the BC Hydro transmission system at Bear Mountain Terminal (BMT) via a 138 kV transmission line designated 1L354. Refer to LOO 4T-BMW-01 for more detailed information.

DKW: There are 48 3-MW wind turbines at DKW with a total capacity of 144 MW. DKW is connected to the BC Hydro Transmission system at Dokie Terminal (DKT) via a 230 kV transmission line designated 2L314. Refer to LOO 4T-DKW-01 for more detailed information.

QTY: There are 79 1.8-MW wind turbines at QTY with a total capacity of 142.2 MW. QTY is connected to the BC Hydro transmission system at Tumbler Ridge Substation (TLR) via a 22.8 km, customer-owned 230 kV transmission line designated 2L315. Refer to LOO 4T-QTY-01 for more detailed information.

MKL: There are total 61 wind turbine units at MKL with a total capacity of 184.6 MW, while 35 units with a capacity of 3.23 MW each and 26 units with a capacity of 2.75 MW each. MKL is connected to the BC Hydro transmission system at Meikle Switching Station (MKT) via a 4.2 km, customer-owned 230 kV transmission line designated 2L339. Refer to LOO 4T-MKL-01 for more detailed information.

The MW output from MCM, BMW, DKW, QTY, and MKL adds to the GMS and PCN generation and contributes to the power flows on the 500 kV transmission systems from GMS/PCN to Williston Substation (WSN) and further to Kelly Lake Substation (KLY).

There is no generation shedding capability at MCM and BMW for Peace system contingencies. Generation shedding capabilities at DKW, QTY, MKL, as well as KMO and FKR/MCY/VOL for Peace 500 kV system contingencies have been incorporated into GMS/PCN Gen Shed RAS scheme. Refer to Attachment 3 – GMS/PCN 500 kV System Remedial Action Schemes (GMS/PCN RAS) for detailed information.

The 500 kV transmission system from GMS/PCN to Ingledow (ING)/Meridian (MDN) consists of two sub-systems: North of KLY 500 kV system and Interior-Lower Mainland (ILM) 500 kV system.

The North of KLY 500 kV system includes:

- two circuits between GMS and WSN (5L1 and 5L2),
- two circuits between PCN and SBK (5L5 and 5L6),
- three circuits between WSN and KLY (5L11, 5L12, and 5L13),
- one circuit each between:
    - GMS and PCN (5L4),
    - PCN and Kennedy Substation (KDS) (5L3),
    - KDS and WSN (5L7).

The ILM 500 kV transmission system consists of circuits:

- two circuits between NIC and MDN (5L82 and 5L83),
- one circuit each between:
    - KLY and NIC (5L87),
    - NIC and ING (5L81),
    - KLY and CKY (5L42),
    - CKY and MDN (5L45),
    - MDN and ING (5L44),
    - KLY and CBN (5L41),
    - CBN and ING (5L40).

There are parallel 230 kV circuits from WSN to KLY, and KLY to Lower Mainland.

Monitoring and RAS arming are undertaken by the Energy Management System's (EMS) advanced applications and tools. RAS arming is implemented in the Transient Stability Analysis by Pattern Matching advanced application (TSA-PM), as described in Sections 5.0 and 6.0. Pre-outage limits and Post-outage generation shedding requirements, including generation shedding at GMS, PCN, DKW, QTY, MKL, KMO, and FKR/MCY/VOL are specified in Attachment 4 for GMS to KLY 500 kV System Operations and in Attachment 6 for ILM 500 kV System Operations.

2.0 RESPONSIBILITIES

BC Hydro operating responsibilities are defined in System Operating Order 1J-11.

3.0 VOLTAGE AND FREQUENCY CONTROL OF THE 500 kV SYSTEM

3.1 Nominal Voltage Schedule for the 500 kV System

As a first priority, 500 kV station voltages should be held as high as possible to maximize stability margins and reduce losses. GMS should be limited to 530 kV when possible to maintain acceptable 230 kV voltage at Tumbler Ridge and 540 kV should be considered the normal upper limit. See SOO 7T-22 for details.

3.2 Overvoltage Protection

Overvoltage protection at WSN will trip 5L1, 5L2, 5L7 (KDS), 5L11, 5L12 and 5L13 in timed sequence if the voltage exceeds 580 kV. Overvoltage protection trips all other lines (except for 5L40 which has no over-voltage protection) in timed sequence as detailed in SOO 7T-22. Reclosing is blocked in all cases.

The first stage over-voltage protection (time delayed) tripping for 5L13 and 5L41 are supervised to prevent tripping if the lead end terminal circuit breakers are opened. This means the near instantaneous follow end tripping will occur if the voltage reaches that setting to allow switching under certain conditions.

3.3 WSN Auto-var Control Scheme

At WSN, an Auto-Var control scheme will automatically switch the following shunt reactors in service: 12RX1, 12RX2, 5RX2, 5RX4, 5RX6. If a system overvoltage (>545 kV) condition exists the reactors will switch in five-second increments starting with 12RX1 and 12RX2 together then 5RX2, 5RX4, 5RX6 will switch in service one at a time until the voltage drops to 530 kV. The scheme must be manually turned on and off at WSN. There is no remote control but there is indication of status in the EMS computer system. The scheme does not switch reactors out of service. See SOO 7T-22 for details.

3.4 Manual Procedures for Overvoltage

For any condition that results in voltage in excess of 550 kV it may be necessary to switch out 500 kV circuits to avoid damage to transformers, reactors and customer's equipment. Voltages above 550 kV should not be tolerated for more than a few minutes and only while switching is in progress.

3.5 Over-frequency Trip of AGC

A local over-frequency relay at GMS will trip GMS generators off AGC when the frequency is 62.5 Hz or greater. PCN units are not part of this scheme.

3.6 Removed

3.7 Removed

4.0 SWITCHING GUIDELINES

4.1 Normal Switching

4.1.1 Output Reduction for Line Switching

As a general rule, when switching out a 500 kV transmission line between GMS to ING, follow the switching guidelines below:

- For 500 kV transmission lines between GMS to KLY, generation output from GMS/PCN and other Peace/North Coast area generation shall be reduced to the level that **NO** gen shed be required for that particular line contingency.
- For 500 kV transmission lines between KLY to ING, generation output from GMS/PCN and other Peace/North Coast area generation, as well as generation output from South Interior, shall be reduced to the level that **NO** gen shed be required for that particular line contingency.

TSA-PM could be used as the primary source for determining the 500 kV transmission line switching limit.

It is desirable to keep the maximum number of units on-line at GMS during 500 kV line outages to increase system stability. When switching out 500 kV circuits or series capacitors, at or near the switching limit, at least seven GMS/PCN units should be on-line. Refer to Section 5.5.1, Section 5.5.2, and Attachment 1 for GMS/PCN minimal units on line pre-contingency requirements and post contingency requirements.

If GMS units must operate below minimum to meet switching restriction, operate below these limits for up to 1/2 hour rather than take units off-line.

4.1.2 Energizing Lines - General

To minimize switching surge over-voltages (and possible flashover problems) 500 kV lines should be energized and de-energized from the 'LEAD' end when possible. GMS is the lead end for 5L1, 5L2, 5L4; PCN for 5L3; WSN for 5L7, 5L11, 5L12, 5L13; ING for 5L40, 5L44; KLY for 5L41; MDN for 5L45; CKY for 5L42 and NIC for 5L87.

Normally, 5L41 should not be energized from CBN 230 kV with 5L40 out of service. If 5L41 is to be energized from CBN, with 5L40 in service, the 500 to 230 kV connection at CBN should first be opened to avoid risk of leaving 5L41 energized solely from the CBN 230 kV side.

Do not energize or de-energize 5L42 with both CKY 5RX1 and KLY 5RX2 connected because of near 100% reactive compensation of the line, which creates close to a resonant circuit at 60 Hz.

4.1.3 Energizing Lines - One Reactor Connected

To reduce the open-end line voltage when one line end reactor is not available, energize 5L1, 5L2, 5L11, 5L12 and 5L13 circuits from the terminal without a reactor.

4.1.4 Energizing Lines - Without Reactors

When a circuit is to be energized without reactors, depress the bus voltage at the energizing end as much as possible.

Where possible, a circuit without both reactors should not be used for synchronization following a system separation.

If 5L13 is to be operated without shunt reactors at both WSN and KLY single pole reclosing on 5L13 must be blocked. 5L13 is not built the same as 5L11 and 5L12 and uses different switching surge arrestors at KLY, MLS and WSN. It is expected that without any shunt reactors a SLG fault will not be cleared within the reclose time. Also, single pole reclose must be blocked if all the neutral reactors on the 500 kV transmission line are bypassed while they are in service. When 5L13 is re-energized without shunt reactors MLS 5CX3 should be used to reduce open-end voltages. WSN bus voltage reduced as low as possible before re-energization. Section 4.1.6 covers energizing lines with series capacitors inserted.

4.1.5 De-energized Lines - Resonance (5L1/2/7/11/12/13)

5L7 De-energized

When 5L7 is de-energized for an extended period of time, WSN 5RX6 should be disconnected from the circuit.

5L1, 5L2, 5L11, 5L12 or 5L13 De-energized
When any of these lines is de-energized for an extended period of time, one of the line reactors should be disconnected from the de-energized circuit.

4.1.6 Energizing 5L1, 5L2, 5L11, 5L12 5L13, 5L41, 5L42 and 5L87 with Series Capacitor Inserted
KDY 5CX1 and 5CX2, MLS 5CX1, 5CX2, 5CX3, CHP 5CX1 CRK 5CX1 and GUI 5CX1 are equipped to be inserted prior to energizing their associated line. This capability is particularly useful when it is difficult to control voltage in order to return one of these lines and its series capacitor bank. With the capacitor bank inserted prior to picking up the circuit, the Ferranti voltage rise is reduced by approximately half.

To energize 5L1, 5L2, 5L11, 5L12, 5L13, 5L41, 5L42 or 5L87 with the series capacitor bank inserted:

- Turn the AUTO INSERT to “DISABLED” position.
- Insert the capacitor bank via supervisory control.
- Energize the line from the LEAD end when possible.
- Put the line and capacitor bank on load.
- Turn the AUTO INSERT to “ENABLED” position.

Do not operate with the AUTO INSERT normally in the “DISABLED” position because this will increase the risk of exposing the bank to fault current when the line auto-recloses onto a fault with the bank still inserted.

4.1.7 De-energizing Lines with Series Capacitors
Series capacitor banks should be bypassed prior to line switching.

4.1.8 Switching at Series Capacitor Stations

- When a de-energized 500 kV line is split at a series capacitor station, the induced voltages due to resonant coupling with parallel lines may cause large currents in its line end reactor neutral. These reactor neutral currents can cause the reactor protection to operate and seal in a transfer trip to the remote end of the line. Prior to splitting a circuit at a capacitor station, the line end reactors should be isolated from the line by opening either the reactor or the line disconnects, and not be reconnected to the line until after the line is tied through at the capacitor station.
- KDY 5CX1, KDY 5CX2, KDY 5CX3, MLS 5CX1, MLS 5CX2, MLS 5CX3, CHP 5CX1, CRK 5CX1 and GUI 5CX1 disconnect operation are interlocked to prevent their bypass disconnects from opening if their associated isolating disconnects are opened.
- If one segment of a two-segment capacitor bank bypasses automatically and cannot be re-inserted, the other segment will normally be left in service. The entire bank should then be considered OOS for generator shedding purposes.
- If unbalance alarms that do not reset occur on series capacitors, shedding should be set up as if the bank is bypassed. This is due to the probability that the bank may bypass on through fault currents.
- During cold weather operation the KDY banks 5CX1, 5CX2 and 5CX3 should not be inserted or bypassed when the dielectric temperature is less than –40 degrees C. See LOO 3T-KDY-01 for detailed procedures.
- KDY 5CX1, KDY 5CX2, MLS 5CX3, CHP 5CX1 and CRK 5CX1 will auto-isolate when a lockout bypass is initiated from some protection. The bypass breaker will close, the bypass disconnect will close, and the isolating disconnects will open. If the bypass breaker fails to close within 200 milliseconds of a command to close, a transfer trip is initiated to both line end terminals.
- MLS 5CX1, MLS 5CX2, MLS 5CX3 and CHP 5CX1 have MOV protection but no spark gap protection. Therefore, some external faults that trigger the MOV

protection may not initiate bank bypass CB operation.

- To bypass via supervisory control of KDY 5CX1, 5CX2, 5CX3, MLS 5CX1, 5CX2, 5CX3, CHP 5CX1, and CRK 5CX1, turn the AUTO INSERT to "DISABLED"; otherwise the bank will automatically reinsert if the line voltage and current are above pre-set values.
- Preferred mode of operation with MLS series capacitors are, where possible, to keep 5L13 and MLS 5CX3 in-service.

4.1.9 Series Capacitor Thermal Ratings

With all lines in service, series capacitor overloads should not occur. However, adjacent line tripping may cause overloads until outputs are adjusted to the new system status output limits, e.g. since the rating of each KDY bank is approximately 2300 A, loss of two 500 kV lines could lead to overloading. Also, since the MLS rating is 1950 A, loss of two WSN-KLY circuits may lead to overloading.

Each series capacitor bank (KDY, MLS, CHP, CRK and GUI) has an overload rating which is the maximum loading that can be accommodated for the corresponding duration of hours, in a 24-hour period.

All banks will alarm on thermal overload. (See SOO 5T-10, each series capacitor station PN sheets, and one-lines for thermal overload ratings and length of times allowed for all overload conditions).

KDY 5CX1, KDY 5CX2, KDY 5CX3, MLS 5CX1, MLS 5CX2, MLS 5CX3, CHP, CRK and GUI will bypass after alarming.

4.1.10 Energizing Transformers and De-Energizing Transformers

It is preferable to energize 500 kV transformers from the 500 kV side to avoid voltage fluctuations associated with high inrush currents.

WSN 500/230 kV transformers and GMS 500/230 kV transformers should be energized via 500 kV CB's with closing resistors or with CB's with POW control units.

GMS Generator Unit Transformer Switching (Reference: LOO 3T-GMS-01):

- GMS T1 through T6, T9 and T10, may be de-energized by opening their respective disconnects once the associated generator is off-line.
- GMS T7 and T8 may only be de-energized by using a 500 kV CB. This is due to deficiencies in the design of the Kearney disconnects, 5D7 and 8. De-energizing T7 or T8 will require both units to be taken off-line. With the 13CB7 and 13CB8 open, the generator transformer will be de-energized from the high voltage side using 500 kV breakers. Once the 500 kV breakers are open the associated disconnect(s) can be operated to isolate the transformer and the 500 kV ring can be restored.

4.1.11 GMS 500 kV Ring Open

When the GMS ring is open, the on-line GMS generators should be arranged so that if 5L1, 5L2 or 5L4 trip, perhaps isolating some generators, there will be a minimum of three GMS generators connected to the system prior to the circuit reclosing.

It is also necessary to block reclosing in some cases to avoid having generators reconnected out of synchronism.

Equipment O.O.S.	Restrictions
GMS 5CB1 OOS	5L1 can reclose on 5CB3 only.
GMS 5CB4 OOS	5L1 can reclose on 5CB2 only.
GMS 5CB6 OOS	5L2 can reclose on 5CB11 only.

GMS 5CB7 OOS	Block 5L4 reclosing.
GMS 5CB10 OOS	Block 5L4 reclosing.
GMS 5B11 OOS	5L1 can reclose on 5CB2 only. G3 and G4 to be shed for loss of 5L1. 5L2 can reclose on 5CB5 only. Block 5L4 reclosing. G7 and G8 to be shed for loss of 5L4.
GMS 5B12 OOS	5L1 can reclose on 5CB3 only. G1 and G2 to be shed for loss of 5L1. 5L2 can reclose on 5CB11 only. G5 and G6 to be shed for loss of 5L2. Block 5L4 reclosing. G9 and G10 to be shed for loss of 5L4.

4.1.12 PCN 500 kV Ring Open

When any of the breakers in the PCN 500 kV ring is open, reclosing is automatically blocked on the appropriate breakers to prevent generating units being reconnected to the system out of synchronism. The following reclose blocking is automatic:

Equipment O.O.S.	Automatic reclose blocking
PCN 5CB1 O.O.S.	PCN 5CB5 reclosing is automatically blocked
PCN 5CB2 O.O.S.	PCN 5CB3 reclosing is automatically blocked
PCN 5CB3 O.O.S.	PCN 5CB2 reclosing is automatically blocked
PCN 5CB5 O.O.S.	PCN 5CB1 reclosing is automatically blocked

4.1.13 5L3 and PCN 5D21/5D41/5RX1 Switching

5L3 at KDS and PCN have open end direct transfer trip to the remote end. Opening of either end circuit breakers will trip the remote end.

Due to line and reactor disconnect limitations at PCN and the location of 5L3 lightning arrester, switching of PCN 5D41 and 5D21 and operation of PCN 5RX1 must be as follows:

Operation of PCN 5D41

PCN 5D41 must not be opened or closed unless 5L3 is de-energized. This control is supervised by low-current detectors in all three phases of reactor 5RX1.

Operation of PCN 5D21

PCN 5D21 must not be opened or closed unless:

- 5L3 is de-energized, AND
- PCN 5D41 is open.

This control is supervised by auxiliary contacts of 5D41.

PCN 5RX1 Operation

PCN 5RX1 must NOT be energized or de-energized unless it is connected to 5LA21/5PT1; i.e. PCN 5D21 is closed.

High transient voltages are generated when reactors are switched without their associated lightning arrester, which at PCN may cause circuit breaker or SF6 bus flashovers.

4.1.14 5L4 OOS

To avoid overvoltage in the PCN/KDS area if 5L7 contingency occurs when 5L4 is OOS, the following pre-outage requirements must be met:

- Keep PCN 500 kV bus voltage at or below 515 kV.
- If neither PCN 5RX1 and SBK 5RX1 are in service then a minimum of four

PCN units are required on line.
- If only one of PCN 5RX1 and SBK 5RX1 are in service then a minimum of three PCN units are required on line.
- If both PCN 5RX1 and SBK 5RX1 are in service then a minimum of two PCN units are required on line.
- (See Section 4.4 for reclose blocking requirements when 5L7 is split at KDY 5CX3 and the KDS terminal is closed).
- Restrict protection work on 5L3, 5L7, and any protection zone at WSN, KDS and PCN that is associated with a 5L3 or 5L7 circuit breaker.

See SOO 7T-12 for RMR requirements.

4.1.15 5L7 OOS

To avoid overvoltage in PCN/KDS area if 5L4 contingency when 5L7 is OOS, the following pre-outage requirements must be met:
- Keep PCN 500 kV bus voltage at or below 515 kV.
- If neither PCN 5RX1 and SBK 5RX1 are in service then a minimum of four PCN units are required on line.
- If only one of PCN 5RX1 and SBK 5RX1 are in service then a minimum of three PCN units are required on line.
- If both PCN 5RX1 and SBK 5RX1 are in service then a minimum of two PCN units are required on line.

- WSN 5RX6 must be taken out of service prior to switching 5L7 in or out of service. WSN 5CB36 will trip via 5RX6 auto-isolation scheme when 5L7 is isolated at KDS and WSN due to operation of 5RX6 neutral over-current protection. This is due to resonance between the line capacitance and the shunt reactance.
- During a 5L7 outage, reclosing on 5L4 should be blocked at PCN (follow end) to protect for a possible out-of-synch condition. If PCN 5L4 reclosing cannot be blocked then the GMS Operator should block GMS 5L4 reclosing until the PCN end can be blocked.
- Restrict protection work on 5L3, 5L4, and any protection zone at GMS, PCN and KDS that is associated with a 5L3 or 5L4 circuit breaker.

See notes for 5L4 OOS for pre-outage concerns, and see SOO 7T-12 for RMR requirements.

4.1.16 KLY 500 kV Bus OOS

With one 500 kV bus OOS at KLY, GMS/PCN will become isolated if an outage occurs on the remaining bus. The loss of the remaining 500 kV bus could result in a very large MSSC. It is prudent to alert GRM (Generation Resource Management) for any increase of CRO (Contingency Reserve Obligation) that may be required.
- TSA-PM will not identify KLY 500 kV bus outage as the MSSC. The Operator must manually calculate the MSSC and enter the value into Reserve Sharing display.
- No non-urgent work is to proceed at KLY station while the bus is OOS.
- Ensure reasonable distribution of Contingency Reserve in other parts of the integrated system and sufficient internal transmission capability for re-dispatch as needed.
- Arm automatic undervoltage load shedding.

4.1.17 5L1 and WSN 5CB13 or 5B11 OOS

Do not operate with both 5L1 and WSN 5CB13 OOS to reduce the risk of connecting 5L61 to WSN 230 kV system following another contingency which resulted in tripping of 5B11 zone. Similarly, do not operate with both 5L1 and WSN

5B11 OOS or 5L1 and WSN 5CB13 OOS.

4.1.18 5L1, 5L2, 5L11 or 5L12 OOS
When any of the circuits 5L1, 5L2, 5L11 and 5L12 is de-energized with circuit breakers at both ends, and both line end reactors are connected, the circuit switcher or circuit breaker associated with the reactor should first be opened before opening any other disconnects in the line. This will minimize the risk of failing to interrupt induced resonance loop current flow with a non circuit switcher disconnect.

4.1.19 5L13 OOS
With 5L13 OOS, do not energize WSN 5RX7 because WSN 5CB7 and 5CB17 are not capable of de-energizing the reactor. When energizing 5L13 use WSN 5CB7 whenever possible as it has point on wave control or staggered pole closing. Normally point on wave is selected for 5CB7.

4.1.20 Open Terminal Keying
All the Peace region and ILM 500 kV lines such as 5L1, 5L2, 5L3, 5L4, 5L40, 5L41, 5L42 5L44, 5L45, 5L81, 5L82, 5L83, 5L61, 5L62, 5L63 and 5L87 are equipped with open terminal transfer trip that will trip the remote end when the circuit is open-ended. Open terminal transfer tripping is provided at both terminals for each line.

4.1.21 WSN Switching Operations for Energizing Lines and Reactors
Initial energization of 5L61 or 5L7 should be done using circuit breakers with closing resistors.

WSN 5L11, 5L12 and 5L13 should be energized with point on wave controlled CB's or staggered pole closing CB's to pick up their associated lines. Circuit breakers with POW, SPC and Closing resistors are designated on one-lines and SCADA controls.

WSN 5CB32 (5RX2) control (tripping and closing) is controlled by the Switchsync F236 Point on Wave relay. WSN 5CB32 should be used to energize and de-energize WSN 5RX2 except when both WSN 5L7 and 5L1 are de-energized.

4.2 Emergency Switching

4.2.1 BPA Ties
When possible the BPA ties should be in service with the maximum number of available units on the bus at GMS and PCN (at reduced voltage if necessary) to minimize overvoltages.

4.2.2 Reduce Bus Voltages
Reduce bus voltages as much as possible prior to switching and regulate voltages after switching by use of reactive compensation to reduce the risk of further system disruption.

4.2.3 Exceeding 550 kV
If an open-end voltage is above 550 kV and the circuit cannot be closed-in within five minutes, switch the circuit out.

4.2.4 All GMS Units O.O.S.
With all units tripped off at GMS, there may be over-voltage at GMS depending on the number of PCN units on line; reduce to one 500 kV circuit between GMS and KLY. No readings are required prior to switching.

4.2.5 Less Than Three Units at GMS
With less than three units at GMS, if voltages on the system exceed 550 kV, only one line should be in service between GMS and WSN.

4.2.6 Separation North of WSN
With GMS/PCN separated north of WSN, if WSN voltage exceeds 550 kV, two of 5L11, 5L12 or 5L13 should be switched out for voltage control as necessary.

4.3 System Separation - Emergency Line Energizing

4.3.1 5L1, 5L2 or 5L4
If there are no GMS units available, the GMS bus can be energized from PCN on 5L4. Power can also be restored to the Peace area using 5L1 or 5L2 from WSN provided both GMS line reactors are energized with the circuit and only one KLY-WSN line is in service.

4.3.2 5L11, 5L12 or 5L13
When the WSN area load cannot be supplied form GMS/PCN, power can be restored by energizing 5L11, 5L12 or 5L13 from KLY providing only one of 5L40 and 5L41 or 5L42 is in service, or other ties and extra reactive is connected to reduce the KLY bus voltage prior to energizing.

4.3.3 5L41 or 5L42
To energize the first line between KLY and CBN/MDN, it is preferred to energize from the south end, using 5L45/42 if possible, because of the considerably lower line charging (320 versus 400 MVARS), and due to the location of the line end reactors. If it is necessary to energize the first line from KLY, another line reactor, 12RX1 and 2RX2 should be used to reduce the KLY bus voltage, and the 230 kV ties to BRT should be in with all available BR1/2 units tied when the line is energized. When 5L41, with 5L40 in service, is to be put in service without its line end reactor, the energizing bus must be reduced below 520 kV prior to energizing. Furthermore, if 5L41 is energized from CBN, the 500 to 230 kV connection at CBN should be opened to avoid risk of energizing 5L41 solely from the CBN 230 kV side.

4.3.4 5L45
Energize from MDN normally. It may be energized from CKY if necessary.

4.3.5 5L3 when PCN 5RX1 is O.O.S.
When 5L4 is in service energize 5L3 from PCN.

With 5L4 out of service energize 5L3 from PCN with a minimum of three units on the bus.

If necessary to energize 5L3 from KDS, the WSN bus voltage should be less than 495 kV.

4.4 Automatic Reclosing

5L1 reclosing is supervised at the lead end (GMS), by power into 5L2 or 5L4, and at the follow end, WSN, by power flow out of 5L2 or 5L7. Reclosing should be set in position 3, and KDY 5CX1 bypass mode shall be selected for 3-pole bypass.

5L2 reclosing is supervised at the lead end, GMS, by power flow into 5L1 or 5L4 and at the follow end, WSN, by power flow out of 5L1 or 5L7. Reclosing should be set in position 3 and KDY 5CX2 bypass mode shall be selected for 3-pole bypass.

The 5L3 reclosing must remain in position 3, 3-pole trip and reclose only. 5L3 reclosing is supervised at the lead end, PCN, by current flow in 5L4 and at the follow end, KDS, by

power out of 5L1 or 5L2 at WSN. 5L3 or 5L7 reclosing at KDS is blocked if the other KDS 5L7 or 5L3 terminal is open. This will prevent an out of synchronism reclose with customer generation connected to Morfee Substation (MFE). Note that if 5L7 is split at KDY 5CX3, and the KDS terminal is closed, 5L3 reclosing must be blocked manually.

5L4 reclosing has the ability for single pole trip and reclose and 3-pole trip and reclose. It is normally set to position 5. 5L4 reclosing is supervised at the lead end, GMS by power into 5L1 or 5L2 and at the follow end, PCN, by power into 5L3.

5L7 reclosing is supervised at the lead end, WSN by power out of 5L1 or 5L2 and at the follow end, KDS by 5L3 line terminal status and current in 5L4 at PCN.

5L11, 5L12 and 5L13 reclosing is supervised at the lead end, WSN by current in at least one of the parallel 500 kV circuits. They are supervised at the follow end, KLY, by restoration of potential and by current in at least one of the parallel circuits.

5L13 is also equipped with single pole trip and auto-reclose, and is normally set in position 5. (MLS 5CX3 is also equipped for single and 3-pole bypass and auto-reinsertion. Normally, 3-pole bypass is selected.)

MLS 5CX1 and 5CX2 should be operated in 3-pole bypass mode with auto reinsertion on. 5L13 single pole reclosing is not permitted when both WSN 5RX7 and KLY 5RX5 are OOS or their neutral reactors are grounded while in service. Single pole trip and reclose is permissible if WSN 5RX7 is OOS as long as KLY 5RX5 remains in service and is not switched OOS for voltage control.

Only 3-phase reclosing is used for 5L40 and 5L41. 5L40 and 5L41 reclosing is supervised by return of potential at the follow end, CBN. 5L42 and 5L87 reclosing is supervised by return of potential at the follow end, KLY. When only one of 5L40/5L41, 5L42 or 5L87 is in service its' reclosing must be turned off.

5L42 reclosing must be left in position 3, 3-pole trip and reclose, until neutral reactors are installed to assist in single pole secondary arc extinction. Remote reclose blocking is available on 5L42 for livelines or system conditions where reclose blocking may be required.

5L45 reclosing is available as single pole trip and reclose or 3-pole trip and reclose. Normally 5L45 reclosing will be in position 5, single pole trip and reclose or 3-pole trip and reclose. Remote reclose blocking is available on 5L45 where reclose blocking may be required for livelines or other system conditions.

When 5L42 is out-of-service, there is no need to block reclosing on 5L45. CKY protection automatically blocks 3-pole reclosing on 5L45 when 5L42 is out-of-service.

When 5L45 is out-of-service, there is no need to block reclosing on 5L42. CKY protection automatically blocks 3-pole reclosing on 5L42 when 5L45 is out-of-service.

When GMS units are armed for shedding for loss of a 500 kV circuit, the units will be shed before that circuit can reclose.

At times of reduced generation at GMS when the power transfer on these circuits is low, parallel line supervision may block auto reclosing.

Auto reclose alarms will be received at the BC Hydro Control Centre when reclosing, successful or unsuccessful, takes place.

5.0 500 kV SYSTEM TRANSFER LIMITS AND GENERATION SHEDDING

5.1 General

The 500 kV transmission system from GMS/PCN to ING/MDN is grouped into two sub-systems:

- GMS to KLY 500 kV system – referred to as North of KLY System
- KLY to (MDN and ING) 500 kV system – referred to as ILM System

The two sub-systems can be considered independent from each other in terms of system conditions and contingencies. Section 5.3.3 provides the post-contingency generation shedding requirement adjustments at GMS/PCN/DKW/QTY/MKL for some combined outages in the North of KLY system and the ILM system.

5.1.1 North of KLY 500 kV System

System Normal operation for the North of KLY system is defined as all GMS to KLY 500 kV equipment in service, including lines, reactors, transformers, and series capacitors.

Pre-contingency restrictions and post-contingency generation shedding requirements for various system conditions and contingencies within the North of KLY have been specified in Attachment 4 – North of KLY 500 kV System Operation.

5.1.2 ILM 500 kV System

System Normal operation for the ILM 500 kV system is defined as all KLY to ING/MDN 500 kV equipment in service, including lines, reactors, transformers, and series capacitors.

Pre-contingency restrictions and post-contingency generation shedding requirements for various system conditions and contingencies within the ILM system have been specified in Attachment 6 – ILM 500 kV System Operation.

5.2 GMS, PCN, DKW, QTY, MKL, KMO, FKR, VOL and MCY Generator Shedding Facilities

Generators at GMS, PCN, DKW, QTY, MKL, KMO, FKR groups, MCY group, and VOL group are selected for shedding for various system contingencies, using a matrix shedding display, via the EMS computer system. T&D System Operations (TDSO) normally has control of the generator shedding system with final backup control provided at GMS.

KMO Operators have the ability to block specific KMO units from shedding according to those units' efficiencies. The arming statuses of the KMO units for the contingencies that will initiate shedding are determined by TSA-PM.

There are six generation shedding groups at FKR. There is one generation shedding group at MCY and VOL each. Components of the eight FKR/MCY/VOL gen shedding groups are listed below:

- Group 1: FKR G1, G2
- Group 2: FKR G4, G5
- Group 3: FKR G7, G8
- Group 4: MCY G1, G2, G3
- Group 5: VOL G1, G2
- Group 6: FKR G3
- Group 7: FKR G6
- Group 8: FKR G9

Generators at KMO, FKR, MCY, and VOL are selected for shedding, based on the total shed amount determined by TSA-PM. There are three levels of gen shedding at KMO and

three levels of gen shedding at FKR/MCY/VOL for GMS to ING 500 kV system contingencies. KMO/FKR/VOL/MCY generation shedding application has been included in Attachment 4.

Attachment 3 summarizes the availability of GMS/PCN 500 kV System Remedial Action Schemes (GMS/PCN RAS).

5.3 Application of Generation Shedding for Contingencies within the North of KLY System

5.3.1 General

Pre-outage limits and Post-contingency gen shed requirements are specified in Tables in Attachment 4 – GMS to KLY 500 kV System Operations, and these pre-outage limits and post-contingency gen shed requirements have been implemented in TSA-PM (Transient Stability Analysis by Pattern Matching). Voltage Stability Limits (VSA) also needs to be adhered to. TSA-PM has included the following rules in its implementation in the same sequence as in the sections below:

5.3.2 Removed.

5.3.3 GMS/PCN/DKW/QTY/MKL Post-contingency Generation Shedding Requirement Adjustments for Outages in the ILM 500 kV System

The following table specifies GMS/PCN/DKW/QTY/MKL post-contingency generation shedding requirement adjustments for the combined outages in the North of KLY system and the ILM 500 kV system.

	System Normal (North of KLY)	• **One of (5L1, 5L2, (5L3 or 5L7 or (5L3 AND 5L7)), or 5L4) OOS; or** • **One of (5L1, 5L2, or (5L3 or 5L7 or (5L3 AND 5L7)) AND One of (MLS 5CX1, MLS 5CX2, or MLS 5CX3) OOS; or** • **Two of (KDY 5CX1, KDY 5CX2, or KDY 5CX3) OOS**	**ALL other System Conditions in North of KLY**
System Normal (ILM 500 kV System)	No adjustment	No adjustment	No adjustment
5L41 OOS	No adjustment	Post-contingency gen shed requirement adjustment for double contingencies of 5L11, 5L12, and 5L13: 200 MW	No adjustment
5L42 OOS	No adjustment	Post-contingency gen shed requirement adjustment for double contingencies of 5L11, 5L12, and 5L13: 320 MW	No adjustment
5L87 OOS	No adjustment	Post-contingency gen shed requirement adjustment for double contingencies of 5L11, 5L12, and 5L13: 200 MW	No adjustment
ALL other ILM 500 kV System outages	No adjustment	No adjustment	No adjustment

5.3.4 Guidelines for Determining Additional Generation Shedding Requirements for GMS Braking Resistors O.O.S.
The generation shedding requirements in Attachment 4 tables are based on two GMS loading resistors being available. Additional generation shedding will be required if more than one GMS Braking Resistors is OOS. TSA-PM will issue an alarm if more than one Braking Resistor is OOS – "Consult Operations Planning for additional gen shed requirements". The following table provides general guidelines for determining additional generation shedding requirements when more than one GMS Braking Resistor is OOS:

GMS Braking Resistors OOS	Guidelines for Determining Additional Generation Shedding Requirements
1	0
2	300 MW
3	600 MW

With more than one resistor out of service, maintaining the maximum number of units on-line (at reduced load, as necessary) will improve security margins prior to any contingency.

5.3.5 Additional Generation Shedding Requirements for PSS OOS.
The operational planning study is based on all PSS in service at GMS. Add generation shed amount for all the contingencies that require gen shed by 25 MW for each on-line unit operating without PSS equipment in service. Any unit operating without its PSS in service is violating WECC Reliability Management System (RMS) criteria and is to be avoided if possible. TSA-PM will check and alarm if there are less than four GMS PSS or three GMS and two PCN PSS in service at all times.

5.3.6 Additional Generation Shedding Requirements at Reduced GMS Generator Voltage
All steady-state limits are based on GMS/PCN voltage of AT LEAST 14.2 kV. In order to maximize GMS / PCN stability limit, GMS/PCN terminal voltage shall operate at or above 14.2 kV. If necessary to operate below 14.2 kV, increase generation shed amount for all the contingencies that require gen shed by the ratio $(14.2/XXX)^2$ where XXX is the reduced voltage.

5.3.7 Removed.

5.3.8 Removed.

5.3.9 Removed.

5.3.10 Removed.

5.4 Application of Generation Shedding for Contingencies within the ILM 500 kV System

Pre-outage restrictions and generation shedding requirements for the contingencies within ILM 500 kV system, such as loss of 5L40, 5L41, 5L42, 5L44, 5L45, 5L87, 5L81, 5L82, 5L83, CHP bypass, CRK bypass, RYC bypass, GUI bypass, AMC 5CX1/CX2 bypass, etc., have been developed based on the power flow dependent method. The pre-outage restrictions and generation shedding requirements under the normal and N-1(one facility out of service) conditions are summarized in Attachment 6.

5.5 General Requirements for Generation Shedding Application

5.5.1 Minimum Number of Generators in Service for Self-excitation and Overvoltage Concerns

A minimum of four equivalent GMS units must be in service at all times except for 5L4 OOS condition (with 5L11/5L12/5L13 in service) and the conditions in the table on Attachment 1 which defines various lines or reactor outages.

Two PCN units can be treated as one equivalent GMS unit except for 5L4, 5L3, or 5L7 OOS conditions (refer to Attachment 1.2 for details).

With 5L11/5L12/5L13 in service, two (2) or more PCN units can **only** be treated as **one** (1) equivalent GMS unit for 5L3 OOS or 5L7 OOS or (5L3 AND 5L7) OOS condition. Any of these units may be in the S/C mode.

If 5L4 OOS condition (with 5L11/5L12/5L13 in service):

- Minimum 3 GMS units are required on line if at least one of two GMS reactors (GMS 5RX1 and GMS 5RX2) and one of three WSN reactors (WSN 5RX2, WSN 5RX4, and WSN 5RX6) are in service, and
- Minimum 4 GMS units are required on line if only one or two GMS reactors (GMS 5RX 1 and GMS 5RX2) is in service, and
- Minimum 5 GMS units are required on line if no reactors are in service at GMS.
- Refer to Note 3 of Attachment 1 for PCN units in service requirements.

If 5L7 OOS condition (with 5L11/5L12/5L13 in service):

- Refer to Note 3 of Attachment 1 for PCN units in service requirements.

5.5.2 Generation Shedding Application at PCN

- Keep at least 110 MW generation output from PCN after shedding.
- Shed GMS units first, and PCN units second. Shed GMS/PCN units by a MW ratio of greater than or equal to 4:1. Alarm if actual armed GMS/PCN MW ratio is violated. Upon receiving the alarm “GMS/PCN shedding ratio incorrect, requires immediate attention”, TDSO System Operators shall correct the ratio by immediate action as much as possible and notify PSOSE (to further discuss any alternatives for proposed GMS/PCN generation shedding requirements including MW and units armed at each plant).

5.5.3 Synchronous Condense Units

Units operating as synchronous condensers should not be shed. They help increase system stability.

5.5.4 Changed System Configuration

After loss of a 500 kV line or capacitor bank, whether gen shedding has taken place or not, the TSA-PM will be automatically triggered by SCADA to produce a new set of recommendations for pre-outage limits and gen shed requirements.

6.0 TSA-PM IMPLEMENTATION

The TSA-PM application in the EMS includes the following implementation from this order:

- Pre-outage restrictions and post-outage generation shedding requirements for contingencies within the ILM 500 kV system in Attachment 6.
- Pre-outage restrictions and post-contingency generation shedding requirements at GMS/PCN/DKW/QTY/MKL/KMO/FKR/MCY/VOL in Attachment 4.
- GMS/PCN/DKW/QTY/MKL/KMO/FKR/MCY/VOL post-contingency generation shedding requirement adjustments for combined outages in the North of KLY system and the ILM 500 kV system.
- GMS/PCN/DKW/QTY/MKL/KMO/FKR/MCY/VOL additional generation shedding requirements, based on unit voltage, PSS/AVR status, braking resistor status, minimum units remaining after shedding.
- Alarms for violations.
- Direct download of the generation pattern to the plant.
- Minimize over-shedding.
- Optimize generation shedding based on unit AGC status.

TSA-PM covers the system conditions that have been studied and are included in Attachment 4, Attachment 5, and Attachment 6.

6.1 Alarms Implemented in TSA-PM

ALARM MESSAGE	REFERENCES
<CTG NAME> - INSUFFICIENT SHEDDING	Section 5.5
MIN # OF UNITS ONLINE VIOLATION AT GMS/PCN	
MIN # OF UNITS ONLINE VIOLATION AT GMS	
<CTG NAME> - GMS/PCN GS<4:1 INFORM PSOSE	
NO MORE THAN 3 RX ALLOWED OOS AT GMS/PCN/WSN	Attachment 1
NUMBER OF ONLINE GMS/PCN PSS VIOLATION	Section 5.3.5
PCN 500KV BUS MUST BE =< 515 KV	Note 3 of Attachment 1
PCN MUOL VIOLATION TO AVOID OVERVOLTAGE FOR C5L7	
PCN MUOL VIOLATION TO AVOID OVERVOLTAGE FOR C5L4	
NO GMS AND PCN UNIT ONLINE	General Alarm for GMS/PCN
VIOLATION_5L41_NORM_RATING	Attachment 6
VIOLATION_5L44_NORM_RATING	
VIOLATION_2L1 PEM OVER RATING_5L41CTG	
VIOLATION_2L1 PEM OVER RATING_5L40CTG	
VIOLATION_2L1 PEM OVER RATING_5L41AND5L83CTG	
CONSULT OPS PLANNING: 230KV PATH MUST BE IN SERVICE	Attachment 4 – Section 1.0
CONSULT OPS PLANNING: ONLY ONE 138KV PATH MAY BE OOS	
GMS_G* MW OUTPUT VIOLATION	Attachment 4 – Section 2.0
VIOLATION_***_NORM_RATING	Attachment 4 – Section 3.0
*** - INSUFFICIENT SHEDDING AT KMO	Attachment 4 – Section 4.0
*** - INSUFFICIENT SHEDDING AT FKR/MCY/VOL	
C*** INSUFFICIENT SHED AT MKL/DKW/QTY/GMS	Attachment 4 – Section 5.0
C*** INSUFFICIENT SHED AT MKL/DKW/QTY/GMS/PCN	
C*** INSUFFICIENT SHED AT MKL/DKW/QTY/PCN	
C*** INSUFFICIENT SHED AT MKL	
C*** INSUFFICIENT SHED AT DKW	

C*** INSUFFICIENT SHED AT QTY	
C*** INSUFFICIENT SHED AT GMS	
** GEN SHED AT KMO LVL 1/2/3 REQUIRED	
** GEN SHED AT FKR/MCY/VOL LVL 1/2/3 REQUIRED	
REDUCE *** < $$$ MW	
C*** MIN # OF UNITS ONLINE VIOLATION AT GMS	
C*** MIN UNITS ONLINE VIOLATION AT PCN	
CONSULT OPS PLANNING FOR GMS SHEDDING AMOUNT	
C*** OVERSHED AT MKL/DKW/QTY/GMS/(PCN)	Attachment 5
C*** UNDERSHED EXCEEDS 30 MW	

7.0 REMOVED

8.0 REVISION HISTORY

Revised By:	Revision Date	Summary of Revision(s)
Jun Lu	31 July 2020	• Attachment 4: Updated KMO / FKR gen shed requirements under the following system conditions: (1) one of the transmission lines OOS; (2) one of the transmission lines AND one of the KDY series capacitor banks OOS; (3) one of the KDY series capacitor banks AND one of the KDY / MLS series capacitor banks OOS, in order to accommodate higher transfers on 2L103, up to 420 MW from RTA to BCH. Multiple tables revised.
Jun Lu / Yingwei Huang	21 August 2020	• Attachment 6: Table 1.2 – 5L40 OOS: updated gen shed requirements for 5L87 contingency • Table 1.9 – 5L87 OOS: updated gen shed requirements for 5L40 contingency.
Jun Lu	13 October 2020	• Section 1 – EMS label and TSA-PM reference updated for issue further in the document. • Section 3.3 – revised label to WSN Auto-Var Control Scheme • Attachment 4 – re-dated. • Attachment 6: o Removed 1L32 continuous ratings and overload ratings in Section 1.1; o Removed pro-outage restrictions in Table 2.5 – 5L83 AND 5L45 OOS related to 1L32 overload; o Updated Section 4.0 - Settings of 2L112 OL RAS and 2L293 OL RAS to Runback NLY PST • Notes on publishing requirements added to cover pages of 7T-13, Att4

		and Att6.
Jun Lu/Amy Lam	03 March 2022	• Section 1 – added information about 5L6 • Section 4.1.14 – updated requirements for 5L4 OOS • Section 4.1.15 – updated requirements for 5L7 OOS • Section 6.1 – Alarm list has been updated • Attachment 1 – updated Note 3, requirements for 5L4 OOS • Attachment 3 – updated GMS RAS functional requirements • Attachment 4 – Separated gen shed requirements for 5L3 and 5L7 individual contingency, and revised gen shed requirements to reflect 5L5 and 5L6 connections between PCN and SBK. Note on topology considerations for application of tables. • Attachment 5 – updated operational instructions for 500 kV islanding scenarios • Attachment 6 - re-dated
Jun Lu	29 September 2022	• Section 1.0 Minor formatting changes in (unmarked). • Section 5.2 has an added reference to Attachment 4 Section 4. Two of the paragraphs have been re-ordered (unmarked). • Attachment 4 – There are notes added to Section 4.0. TSA-PM always calculates a shedding amount, but the arming is based on the table requirements in Section 5. The gen shed amount is only applicable when FKR/KMO level 1/2/3 is actually armed in accordance with the specific table equations for topologies in Section 5 of the Attachment. A further note was added to aid in understanding the unit preferences in arming for KMO. The preferences can be found in 7T-30, and are adhered to in the Attachment 4 arming requirements. These preferences have been implemented in this release of the 7T-13 TSA-PM code. • Attachment 6 – First bullet in Section 3.0 of the Attachment has been updated for the referenced Section numbers (5.5.1 and 5.5.2) in the main body, for the minimum units on line requirements at GMS & PCN.

***Only the last 5 revisions are retained.**

Attachment 1 Loss of WSN to KLY 500 kV Lines (Single or Double)

General:
Generation shedding for single or double contingencies of (5L11, 5L12 or 5L13) is provided primarily to maintain transient stability under normal system conditions and with one or two of the WSN to KLY circuit already out of service, to limit the over-frequency in the Northern Region following islanding. Considerable over-frequency may still occur if all GMS/PCN units were heavily loaded and some GMS/PCN/WSN reactors were out of service prior to the separation because the shedding requirement is dependent on the transmission status of only the Northern Region 500 kV circuits and reactors.

5L11, 5L12 and 5L13 shedding initiations from WSN and KLY are continuous status indications to cover both simultaneous and non-simultaneous tripouts. These facilities can therefore be used to cover loss of one circuit while the other is out of service for maintenance, etc. However, the individual 5L11, 5L12 and 5L13 selections must be maintained to permit different shedding selections for the differing status of the existing MLS series capacitor banks, 5CX1, 5CX2 and 5CX3.

Only three-phase tripping of 5L13 will initiate the double contingency shedding involving 5L13.

Attachment 1.1 All 500 kV WSN-KLY Lines in Service

Refer to TSA-PM for shedding requirements.

Attachment 1.2 One or Two of 5L11, 5L12 or 5L13 Not in Service

With one or two of 500 kV WSN-KLY line OOS, the selection should be made to match as near as possible the Northern Region plus North Coast region (RTA and Forrest Kerr IPP) generation to load balance. A transfer of 150 MW maximum in either direction on the WSN to KLY 230 kV ties following loss of the remaining two or one 500 kV line is expected to maintain synchronism between WSN and KLY. However this selection will not always be possible due to the need to adhere to the "Minimum Number of Units On Line After Shedding" which follows.

If one or two of 5L11, 5L12 or 5L13 is out of service, then the following table must be adhered to prevent self-excitation and over voltage following loss of the 500 kV line(s) between GMS to KLY. For the conditions of:

- one or two of 5L11, 5L12, or 5L13 OOS, or
- one or two of 5L11, 5L12, or 5L13 OOS, and 5L1 or 5L2 OOS,

Two PCN units can be treated as one equivalent GMS unit to meet the requirement specified in the table, if PCN is part of the gen shed requirement for that particular contingency. For these conditions at least one GMS unit must be kept on line before and after shedding.

For the conditions of:

- one or two of 5L11, 5L12, or 5L13 OOS, and 5L3 or 5L7 OOS

Two or more PCN units can only be treated as one equivalent GMS unit, if PCN is part of the gen shed requirement for that particular contingency. This means that four PCN units can only be considered one equivalent GMS unit.

Attachment 1.3 Equivalent GMS Units to be On line Pre-outage and After Loss of the 500 kV Lines/Line Between GMS-KLY

Reactors De-energized (Note 1)	One or two of 5L11, 5L12, 5L13 OOS	One or two of 5L11, 5L12, 5L13 **AND** One of 5L1, 5L2 OOS (Note 2)	One or two of 5L11, 5L12, 5L13 **AND** One of 5L3, 5L7 OOS (Note 2)	One or two of 5L11, 5L12, 5L13 **AND** 5L4 OOS
NONE	4	2	3 (Note 3)	4 (Note 3)
1	5	3	4 (Note 3)	5 (Note 3)
2	6	4	5 (Note 3)	6 (Note 3)

3	7	5	6 (Note 3)	7 (Note 3)

Note 1 "Reactors De-energized" refers to any GMS reactors, PCN reactor, WSN 5RX1, WSN 5RX2, WSN 5RX4 and WSN 5RX6 (WSN 5L1, 2, 7, 61 line reactors) that are not energized.

Note 2 Lines OOS in this table refers to the lines only, not including their associated line end reactors. See Note 1.

Note 3 To avoid over-voltage in PCN/KDS area if 5L7 contingency when 5L4 is OOS, or if 5L4 contingency when 5L7 is OOS, the following pre-outage requirements must be met:

- Keep PCN 500 kV bus voltage at or below 515 kV.
  - If both PCN reactor 5RX1 and SBK reactor 5RX1 out of service, a minimum of four PCN units are required on line.
  - If one of PCN reactor 5RX1 and SBK reactor 5RX1 out of service, a minimum of three PCN units are required on line.
  - If both PCN reactor 5RX1 and SBK reactor 5RX1 in service, a minimum of two PCN units are required on line.

Attachment 2 **Removed**

Attachment 3 GMS/PCN 500 kV System Remedial Action Schemes (GMS/PCN RAS)

No.	Contingency	Generation Shedding at									DTT			WSN Shunt Reactor Fast Switching In	
		GMS	PCN	DKW via DKT	QTY via TLR	MKL via MKT	GenShed Speed At GMS/PCN/ DKW/QTY/ MKL (cycles)	Three Levels of Shed at KMO	Three Levels of Shed at FKR/MCY /VOL	GenShed Speed At KMO/FKR/ MCY/VOL (cycles)	5L1	5L2	5L12	12RX1/ 12RX2 (Note 5)	5RX2/ 5RX4/ 5RX6 (Note 5)
1	5L1 (from GMS)	A	A	A	A	A	9	A	A	14					
2	5L2 (from GMS)	A	A	A	A	A	9	A	A	14					
3	5L3	A	A	A	A	A	9	A	A	14					
4	5L11 (from WSN)	A	A	A	A	A	9	A	A	14					
5	5L12 (from WSN)	A	A	A	A	A	9	A	A	14					
6	5L41 (from CBN)	A	A	A	A	A	9	A	A	14					
7	5L42 (from CKY)	A	A	A	A	A	9	A	A	14					
8	5L45 (from CKY)	A	A	A	A	A	9	A	A	14					
9	5L87 (from NIC)	A	A	A	A	A	9	A	A	14					
10	5L51 AND 5L52 (from ING) (Note 3)	A	A	A	A	A	12 (Note 1)	A	A			A	A		
11	BPA Westside RAS (from Dittmer CC and Munro CC)	A	A	A	A	A	12 (Note 1)	A	A						
12	MLS 5CX1 AND NOT 5L11	A	A	A	A	A	10.5	A	A	15.5					
13	MLS 5CX2 AND NOT 5L12	A	A	A	A	A	10.5	A	A	15.5					
14	(5L42 AND 5L45) OR (5L30 AND 5L32) OR (5L29 AND 5L31) OR (DMR T1 AND DMR T2)	A	A	A	A	A	12 (Note 1)	A	A	14					
15	5L4 (from GMS)	A	A	A	A	A	9	A	A	14					
16	5L40 (from CBN)	A	A	A	A	A	9	A	A						
17	BPA Pacific AC RAS (from Dittmer CC and Munro CC)	A	A	A	A	A	9	A	A						
18	5L11 AND 5L12 (logic at GMS)	A	A	A	A	A	9	A	A	14	A			A	A
19	5L13 Three Phase (from WSN)	A	A	A	A	A	9	A	A	14					
20	5L13 Single Phase (from WSN)	A	A	A	A	A	9	A	A						
21	5L11 AND 5L13 (logic at GMS)	A	A	A	A	A	9	A	A	14	A			A	A
22	5L12 AND 5L13 (logic at GMS)	A	A	A	A	A	9	A	A	14	A	A		A	A
23	MLS 5CX3 AND NOT 5L13	A	A	A	A	A	10.5	A	A	15.5					
24	CHP 5CX1 AND NOT 5L41	A	A	A	A	A	10.5	A	A						
25	5L51 (from ING)	A	A	A	A	A	12 (Note 1)	A	A						
26	5L52 (from ING)	A	A	A	A	A	12 (Note 1)	A	A						
27	CRK 5CX1 AND NOT 5L42	A	A	A	A	A	10.5	A	A						
28	5L1 AND 5L2 (logic at GMS)	A	A	A	A	A	9	A	A	14					
29	5L1 AND 5L3 (logic at GMS)	A	A	A	A	A	9	A	A	14					
30	5L1 AND 5L7 (logic at GMS)	A	A	A	A	A	9	A	A	14					
31	5L2 AND 5L3 (logic at GMS)	A	A	A	A	A	9	A	A	14					
32	5L2 AND 5L7 (logic at GMS)	A	A	A	A	A	9	A	A	14					
33	KDY 5CX1 AND NOT 5L1	A	A	A	A	A	10.5	A	A	15.5					
34	KDY 5CX2 AND NOT 5L2	A	A	A	A	A	10.5	A	A	15.5					
35	KDY 5CX3 AND NOT 5L3/7	A	A	A	A	A	10.5	A	A	15.5					
36	5L44 (from ING)	A	A	A	A	A	12 (Note 1)	A	A	14					
37	5L81 AND 5L82 (logic at GMS)	A	A	A	A	A	12 (Note 1)	A	A	14					
38	5L1/2/3/4/7/11/12 Multi-phase fault	A	A	A	A	A	9	A	A	14					
39	5L81 AND 5L83	A	A	A	A	A	12 (Note 1)	A	A						
40	5L82 AND 5L83	A	A	A	A	A	12 (Note 1)	A	A						
41	5L41 AND 5L83	A	A	A	A	A	12 (Note 1)	A	A						
42	5L61 (from WSN)	A	A	A	A	A	9	A	A	14					
43	5L7	A	A	A	A	A	9	A	A	14					
44	5L62	A	A	A	A	A	12								
45	5L63	A	A	A	A	A	12								
46	5L1 AND 5L4	A	A	A	A	A	9								
47	5L2 AND 5L4	A	A	A	A	A	9								
	Speed Requirements (Cycles)										10	10/ 13[4]	13	13	12

Notes:

- Note 1: This function only applies to gen shed at GMS/PCN, no gen shed at DKW/QTY/MKL.
- Note 2: “A” means “Available for arming”.
- Note 3: The double contingency input signal – 5L51 & 5L52 shall cover both N-2 and N-1-1 contingencies. For example, contingency signal of 5L51 & 5L52 shall cover both simultaneous loss of 5L51 and 5L52, and loss of 5L51 when 5L52 is OOS or loss of 5L52 when 5L51 is OOS.
- Note 4: The speed requirement for tripping 5L2 for 5L51 and 5L52 related contingencies (N-2, or N-1-1) is 13 Cycles, while the speed for tripping 5L2 triggered by the contingencies related to 5L11, 5L12 or 5L13 will be 10 cycles.
- Note 5: 12RX1/12RX2 will be combined as one signal for switching, while 5RX2, 5RX4, and 5RX6 are switched individually.

Attachment 4 North of KLY 500 kV System Operations

The North of KLY 500 kV System Operations pre-outage restriction and generation shedding requirement tables is posted to the Site Information System (SIS) as a separate document (SOO 7T-13 Attachment 4). The Attachment is distributed with the electronic notification of the update of this Order.

Attachment 5 Peace Generation Shedding not covered in tables – Islanding Scenarios

Attachment 5.1 (a) 5L1 or (5L1 AND 5L4) Out of Service

GMS/PCN generation shedding rules for double contingencies of 500 kV line 5L2 & 5L3, and 5L2 & 5L7.
(Applicable to any system conditions where contingencies will result in GMS/PCN area islanding from North of WSN).

System conditions	Contingencies	Generation shedding rules	Comments
5L1 OOS	5L2 & 5L3	GMS/PCN/DKW/QTY/MKL shedding = 5L2 flow (GMS) + 5L3 flow (PCN) – 60 MW – (MCM + BMW + MLW + ZBW generation).	Notes 1,2,3
	5L2 & 5L7	GMS/PCN/DKW/QTY/MKL shedding = 5L2 flow (GMS) + 5L7 flow (KDS) – 60 MW – (MCM + BMW + MLW + ZBW generation).	Notes 1,2,3

Note 1 Arm DKW/QTY/MKL first. When possible, maintain unarmed GMS/PCN generation at a level not exceeding the GMS area load plus 60 MW. This will ensure the post outage over-frequency in the islanded area is not too high. 30 MW under shedding and 10 MW over shedding are acceptable. GMS Area Load = GMS 500 kV to GMS 138 kV and GMS 230 kV flow + (5L5 + 5L6) PCN + (MCM + BMW + DKW + QTY + MKL + MLW + ZBW) generation.

Note 2 60 MW was considered as the acceptable surplus generation from islanding over-frequency perspective in GMS/PCN area.

Note 3 Refer to Section 5.5.1 and Section 5.5.2 for the required minimum units on line post shedding. Required on line units can be either generators or synchronous condensers.

Note 4

- See Section 4.1.3 regarding energizing 5L1 with only one reactor connected.
- See Section 4.1.5.2 regarding disconnecting one line end reactor when the line is de-energized because of resonance concerns.
- See Section 4.1.6 regarding the ability to insert KDY 5CX1 before energizing 5L1.
- See Section 4.1.14 regarding pre-outage requirements under 5L4 OOS condition.
- See Section 4.1.17 regarding the concerns of both 5L1 and 5CB13 OOS.
- See Section 4.1.18 regarding, when 5L1 is de-energized, using a circuit switcher to break the induced current.

Attachment 5.1 (b) 5L2 or (5L2 AND 5L4) Out of Service

GMS/PCN generation shedding rules for double contingencies of 500 kV line 5L1 & 5L3, and 5L1 & 5L7.
(Applicable to any system conditions where contingencies will result in GMS/PCN area islanding from North of WSN).

System conditions	Contingencies	Generation shedding rules	Comments
5L2 OOS	5L1 & 5L3	GMS/PCN/DKW/QTY/MKL shedding = 5L1 flow (GMS) + 5L3 flow (PCN) – 60 MW – (MCM + BMW + MLW + ZBW generation).	Notes 1,2,3

	5L1 & 5L7	GMS/PCN/DKW/QTY/MKL shedding = 5L1 flow (GMS) + 5L7 flow (KDS) – 60 MW – (MCM + BMW + MLW + ZBW generation).	Notes 1,2,3

Note 1 Arm DKW/QTY/MKL first. When possible, maintain unarmed GMS/PCN generation at a level not exceeding the GMS area load plus 60 MW. This will ensure the post outage over-frequency in the islanded area is not too high. 30 MW under shedding and 10 MW over shedding are acceptable.
GMS Area Load = GMS 500 kV to GMS 138 kV and GMS 230 kV flow + (5L5 + 5L6) PCN + (MCM + BMW + DKW + QTY + MKL+ MLW + ZBW) generation.

Note 2 60 MW was considered as the acceptable surplus generations from islanding over-frequency perspective in GMS/PCN area.

Note 3 Refer to Section 5.5.1 and Section 5.5.2 for the required minimum units on line at GMS and PCN post shedding. Required on line units can be either generators or synchronous condensers.

Note 4

- See Section 4.1.3 regarding energizing 5L2 with only one reactor connected.
- See Section 4.1.5.2 regarding disconnecting one line end reactor when the line is de-energized because of resonance concerns.
- See Section 4.1.6 regarding the ability to insert KDY 5CX2 before energizing 5L2.
- See Section 4.1.14 regarding pre-outage requirements under 5L4 OOS condition.
- See Section 4.1.18 regarding, when 5L2 is de-energized, using a circuit switcher to break the induced current.

Attachment 5.1 (c) 5L3 or 5L7 or (5L3 AND 5L7) or [(5L3 or 5L7 or (5L3 AND 5L7)) AND 5L4] Out of Service

GMS/PCN generation shedding rules for double contingencies of 500 kV line 5L1 & 5L2 resulting in islanding of GMS/PCN area.
(Applicable to any system conditions where contingencies will result in GMS/PCN area islanding from North of WSN).

System conditions	Contingencies	Generation shedding rules	Comments
5L3 or (5L3 AND 5L7) OOS	5L1 & 5L2	GMS/PCN/DKW/QTY/MKL shedding = 5L1 flow (GMS) + 5L2 flow (GMS) –60 MW – (MCM + BMW + MLW + ZBW generation).	Notes 1,2,3

Note 1 Arm DKW/QTY/MKL first. When possible, maintain unarmed GMS/PCN generation at a level not exceeding the **GMS Area Load** plus 60 MW. This will ensure the post outage over-frequency in the islanded area is not too high. 30 MW under shedding and 10 MW over shedding are acceptable.

- **GMS Area Load** = GMS 500 kV to GMS 138 kV and GMS 230 kV flow + (5L5 + 5L6) PCN + (MCM + BMW + DKW + QTY + MKL + MLW + ZBW) generation.

Note 2 60 MW was considered as the acceptable surplus generation from islanding over-frequency perspective in GMS/PCN area.

Note 3 Refer to Section 5.5.1 and Section 5.5.2 for the required minimum units on line at GMS and PCN post shedding. Required on line units can be either generators or synchronous condensers.

Note 4

- See Section 4.1.13 regarding PCN disconnect switching and PCN 5RX1 operation.
- See Section 4.1.14 and Section 4.1.15 regarding pre-outage requirements under 5L4 OOS condition and 5L7 OOS condition. The same pre-outage requirements also apply to (5L4 AND 5L7) OOS conditions.

Attachment 5.2 (a) 5L11 Out of Service

Note 1 GMS/PCN shedding rules for loss of the remaining WSN – KLY 500 kV line with WSN-KLY 230 kV path intact:

If F5L11_12_13_WSN + F2L96_WSN > 1000 MW, then
- KMO gen shed: Level 2
- FKR/VOL/MCY gen shed: Level 3

If 350 MW < F5L11_12_13_WSN + F2L96_WSN <= 1000 MW, then
- KMO gen shed: Level 1
- FKR/VOL/MCY gen shed: Level 1

AND
- GMS/PCN/DKW/QTY/MKL shed = (F5L11_12_13_WSN + F2L96_WSN – 150 MW) – KMO/FKR/VOL/MCY Armed Gen Shed
- Arm DKW/QTY/MKL first

Note 2 GMS/PCN shedding rules for loss of the remaining WSN – KLY 500 kV line with WSN-KLY 230 kV path opened:

If F5L11_12_13_WSN – (MCM + BMW) generation > 500 MW, then
- KMO gen shed: Level 2
- FKR/VOL/MCY gen shed: Level 3

If 150 MW < F5L11_12_13_WSN – (MCM + BMW) generation <= 500 MW, then
- FKR/VOL/MCY gen shed: Level 1

AND
- GMS/PCN/DKW/QTY/MKL shed = (F5L11_12_13_WSN – (MCM + BMW) generation - 30 MW) – KMO/FKR/VOL/MCY Armed Gen Shed
- Arm DKW/QTY/MKL first

Notes for 5L11 Out of Service
- See Section 4.1.3 regarding switching with one line end reactor out-of-service.
- See Section 4.1.5.2 regarding resonance concerns with line de-energized.
- See Section 4.1.6 about capability of energizing 5L11 with MLS 5CX1 inserted.
- See Section 4.1.17 regarding concerns about 5L1 and 5L11 out-of-service at the same time.
- See Section 4.1.18 regarding restrictions on operating line-end disconnects on a de-energized line.
- See Attachment 1 regarding significant restrictions on GMS_PCN_OUT MW output with 5L11 out-of-service.

Attachment 5.2 (b) 5L12 Out of service

Note 1 GMS/PCN shedding rules for loss of the remaining WSN-KLY 500 kV line with WSN-KLY 230 kV path intact:

If F5L11_12_13_WSN + F2L96_WSN > 1000 MW, then
- KMO gen shed: Level 2
- FKR/VOL/MCY gen shed: Level 3

If 350 MW < F5L11_12_13_WSN + F2L96_WSN <= 1000 MW, then
KMO gen shed: Level 1
FKR/VOL/MCY gen shed: Level 1

AND
- GMS/PCN/DKW/QTY/MKL shed = (F5L11_12_13_WSN + F2L96_WSN – 150 MW) – KMO/FKR/VOL/MCY Armed Gen Shed
- Arm DKW/QTY/MKL first

Note 2 GMS/PCN shedding rules for loss of the remaining WSN – KLY 500 kV line with WSN-KLY 230 kV path opened:

If F5L11_12_13_WSN – (MCM + BMW) generation > 500 MW, then
- KMO gen shed: Level 2
- FKR/VOL/MCY gen shed: Level 3

If 150 MW < F5L11_12_13_WSN – (MCM + BMW) generation <= 500 MW, then
- FKR/VOL/MCY gen shed: Level 1

AND
- GMS/PCN/DKW/QTY/MKL shed = (F5L11_12_13_WSN – (MCM + BMW) generation - 30 MW) – KMO/FKR/VOL/MCY Armed Gen Shed
- Arm DKW/QTY/MKL first

Notes for 5L12 Out of Service
- See Section 4.1.3 regarding switching with one line end reactor out-of-service.
- See Section 4.1.5.2 regarding resonance concerns with line de-energized.
- See Section 4.1.6 about capability of energizing 5L12 with MLS 5CX2 inserted.
- See Section 4.1.18 regarding restrictions on operating line-end disconnects on a de-energized line.
- See Attachment 1 regarding significant restrictions on GMS_PCN_OUT MW output with 5L12 out-of-service.

Attachment 5.2 (c) 5L13 Out of Service

Note 1 GMS/PCN shedding rules for loss of the remaining WSN – KLY 500 kV line with WSN-KLY 230 kV path intact:

If F5L11_12_13_WSN + F2L96_WSN > 1000 MW, then
- KMO gen shed: Level 2
- FKR/VOL/MCY gen shed: Level 3

If 350 MW < F5L11_12_13_WSN + F2L96_WSN <= 1000 MW, then
- KMO gen shed: Level 1
- FKR/VOL/MCY gen shed: Level 1

AND
- GMS/PCN/DKW/QTY/MKL shed = (F5L11_12_13_WSN + F2L96_WSN – 150 MW) –KMO/FKR/VOL/MCY Armed Gen Shed
- Arm DKW/QTY/MKL first

Note 2 GMS/PCN shedding rules for loss of the remaining WSN – KLY 500 kV line with WSN-KLY 230 kV path opened:

If F5L11_12_13_WSN – (MCM + BMW) generation > 500 MW, then
- KMO gen shed: Level 2
- FKR/VOL/MCY gen shed: Level 3

If 150 MW < F5L11_12_13_WSN – (MCM + BMW) generation <= 500 MW, then
- FKR/VOL/MCY gen shed: Level 1

AND
- GMS/PCN/DKW/QTY/MKL shed = (F5L11_12_13_WSN – (MCM + BMW) generation – 30 MW) – KMO/FKR/VOL/MCY Armed Gen Shed
- Arm DKW/QTY/MKL first

Notes for 5L13 Out of Service

- See Section 4.1.3 regarding switching with one line end reactor out-of-service.
- See Section 4.1.5.2 regarding resonance concerns with line de-energized.
- See Section 4.1.6 about capability of energizing 5L13 with MLS 5CX3 inserted.
- See Section 4.1.19 regarding restrictions on use of WSN 5RX7 when 5L13 is out-of-service.
- See Attachment 1 regarding significant restrictions on GMS_PCN_OUT MW output with 5L13 out-of-service.

Attachment 5.3 **Removed**

Attachment 5.4 **Removed**

Attachment 6 **ILM 500 kV System Operation**

An electronic copy of the ILM 500 kV System pre-outage restriction and generation shedding requirement tables is posted to the Site Information System (SIS) as a separate document under this same title (SOO 7T-13 Att6). The Attachment is distributed with the electronic notification of the update of this Order. A hard copy is located on the Generation Co-ordinator Desk in the Control Centre.

Note: Table 2.2 to Table 2.14 are just for references purpose. The pre-outage restrictions and post-contingency generation shedding requirements in these tables were the operational planning study results under the system configurations before 5L83 was in service in year 2015, and do not reflect the current system operating conditions. These tables shall be used with caution.

Attachment 7 **Removed**