Transmission Grid Flexibility

BPA Grid Transformation Workshop

March 20, 2013

Motivation

- Existing and forward looking challenges on the transmission system include:
  - Transfers on the main grid are limited by lower capacity parallel facilities
  - System outages are difficult to plan
  - Managing Variable generation and increasing dynamic transfers need to be investigated
  - Increasing capital cost for new lines and difficulty acquiring right of ways
- Can increasing the main grid network controllability address these problems?

What can concepts are there to improve network flexibility and controllability?

- Power flow control devices (FACTS) and network flow control devices (phase angle regulators, controllable series impedance)
- Automatic reactive power and voltage control
- Planning philosophies (radial versus parallel, loops, and meshed systems)
- Automatic sectionalizing, generation dropping, load shedding, or demand response
- Short Term Ratings
- Improved real time state awareness: thermal limits, reactive margins, and stability boundaries
- Re-dispatch markets to relieve congestion that may only exist for a low number of hours a year
- Others…

Historical WECC Flow Control Measures

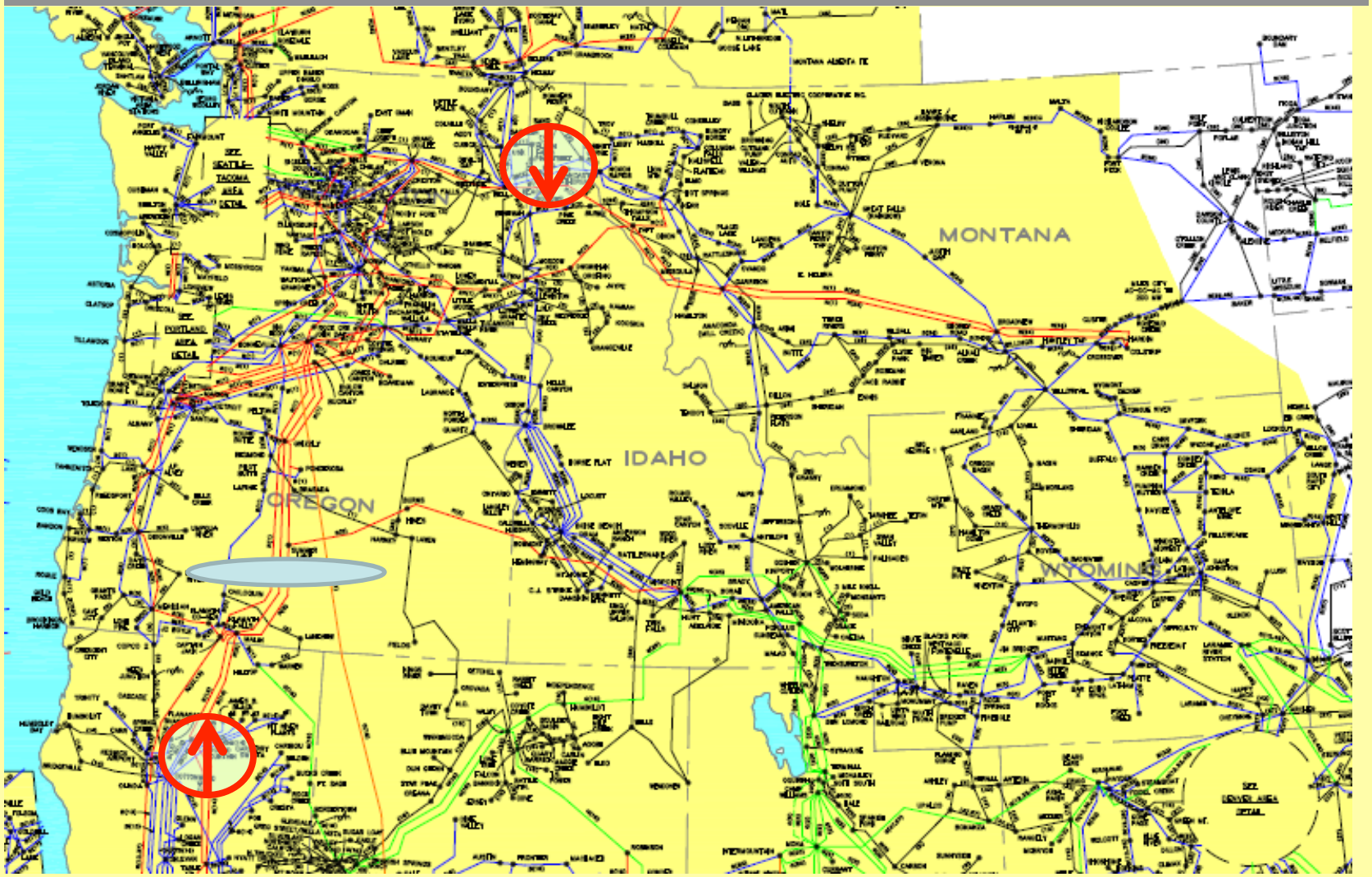
Bill Mittelstadt

Grid Transformation March 20, 2013

Network Flexibility

- Generation Re-dispatch
- AC Intertie series capacitor insertion/ bypass
- HVDC Intertie flow control
- Phase shifter control
- Controlled Islanding

Generation Redispatch To Relieve Flow

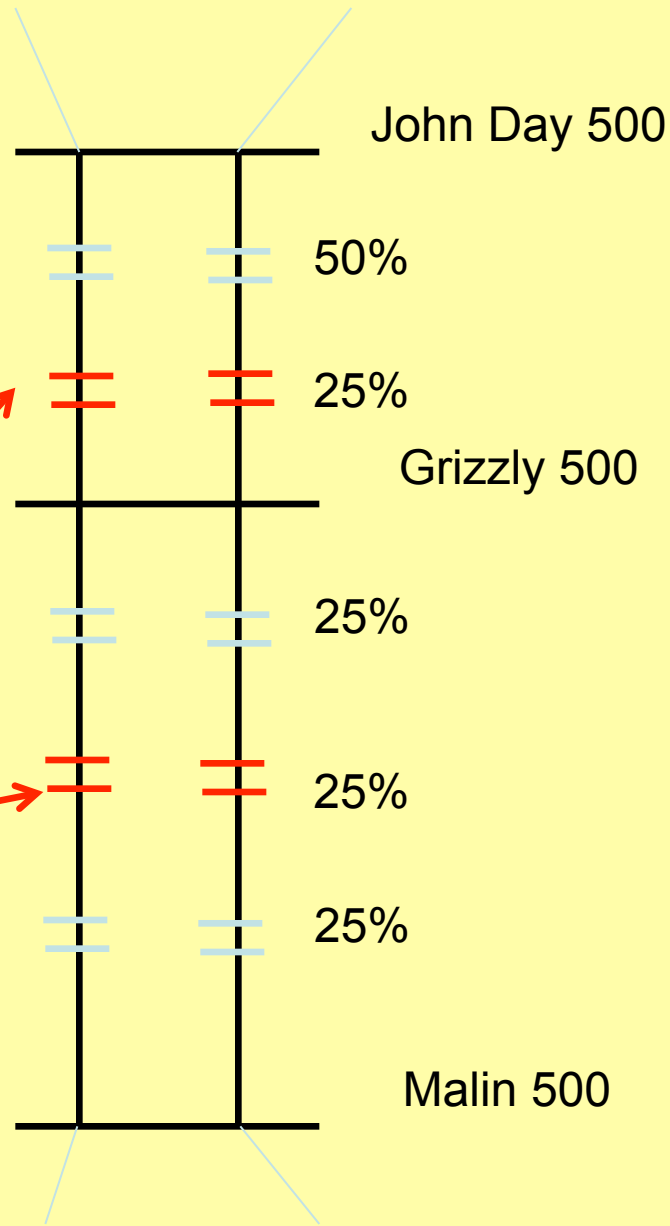


Proprietary Information

Pacific AC Intertie

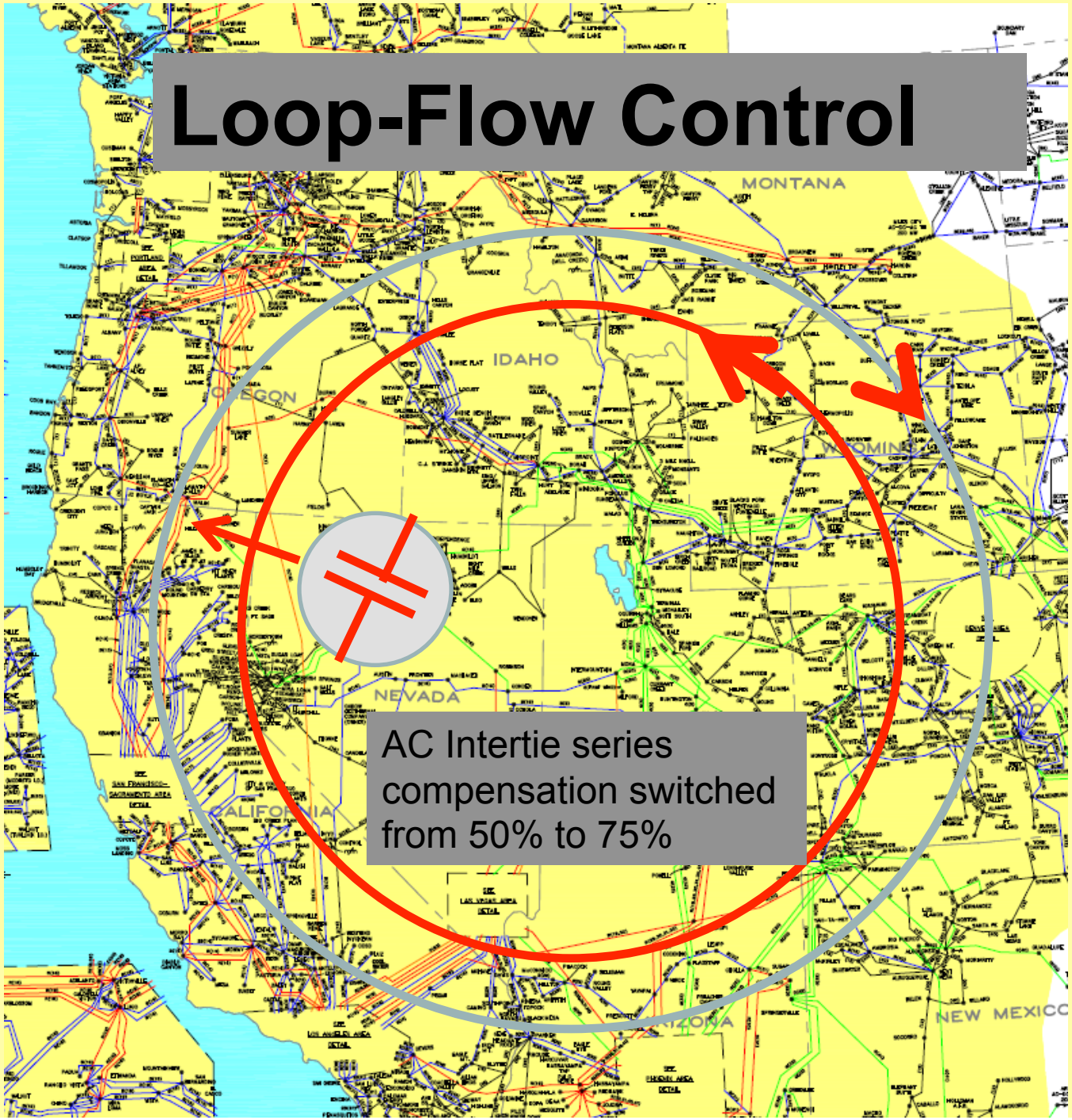
- The two-line 500 kV Pacific AC Intertie was began in 1965 eventual reaching a rating of 3200 MW through control actions.
- A third line was added in 1993 raising the capacity to 4800 MW (California – Oregon Transmission Project or COTP).

Early Pacific AC Intertie Use of Switched Series Capacitors



Insert for loss of the parallel line to maintain same impedance

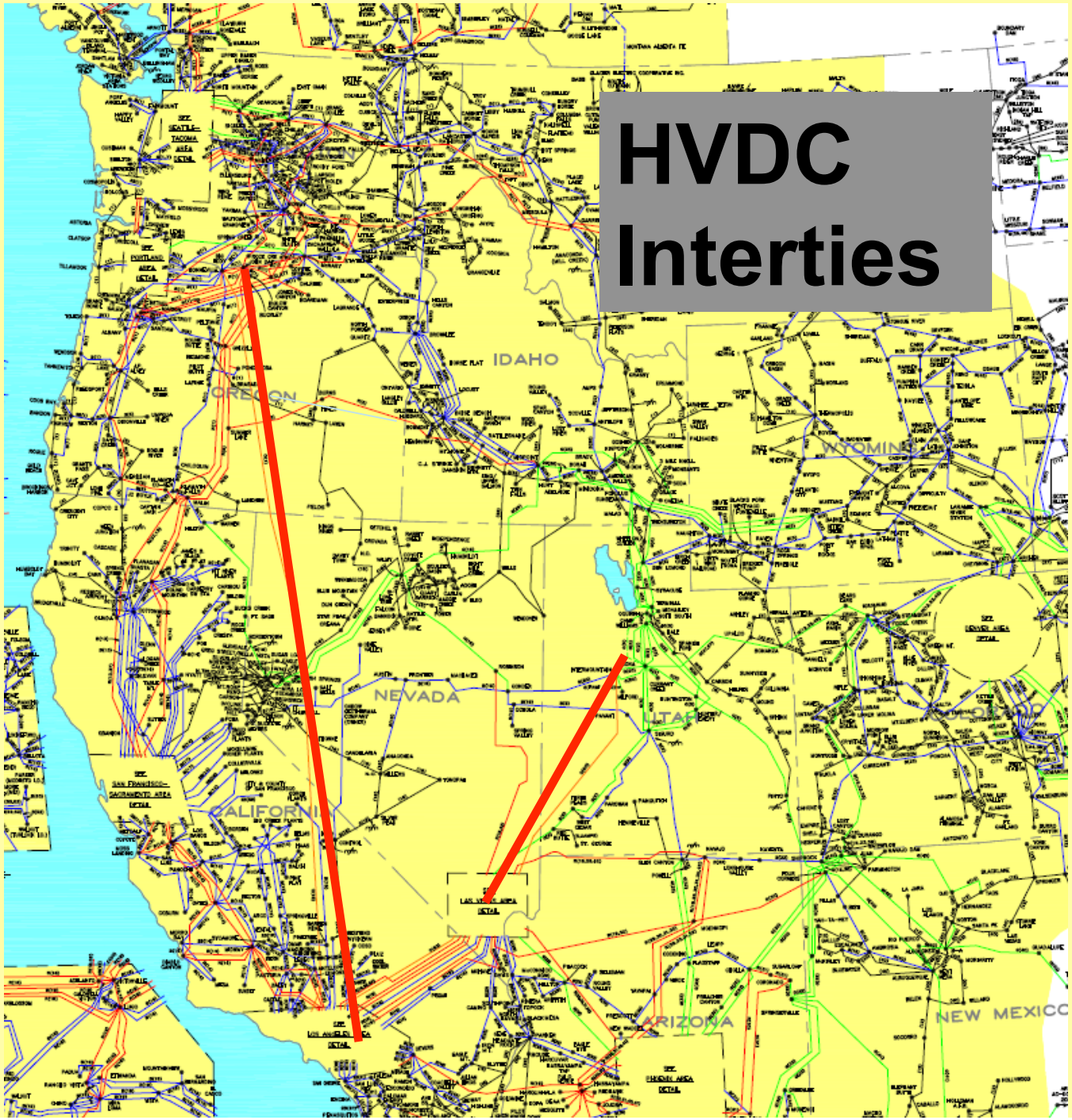
Loop-Flow Control



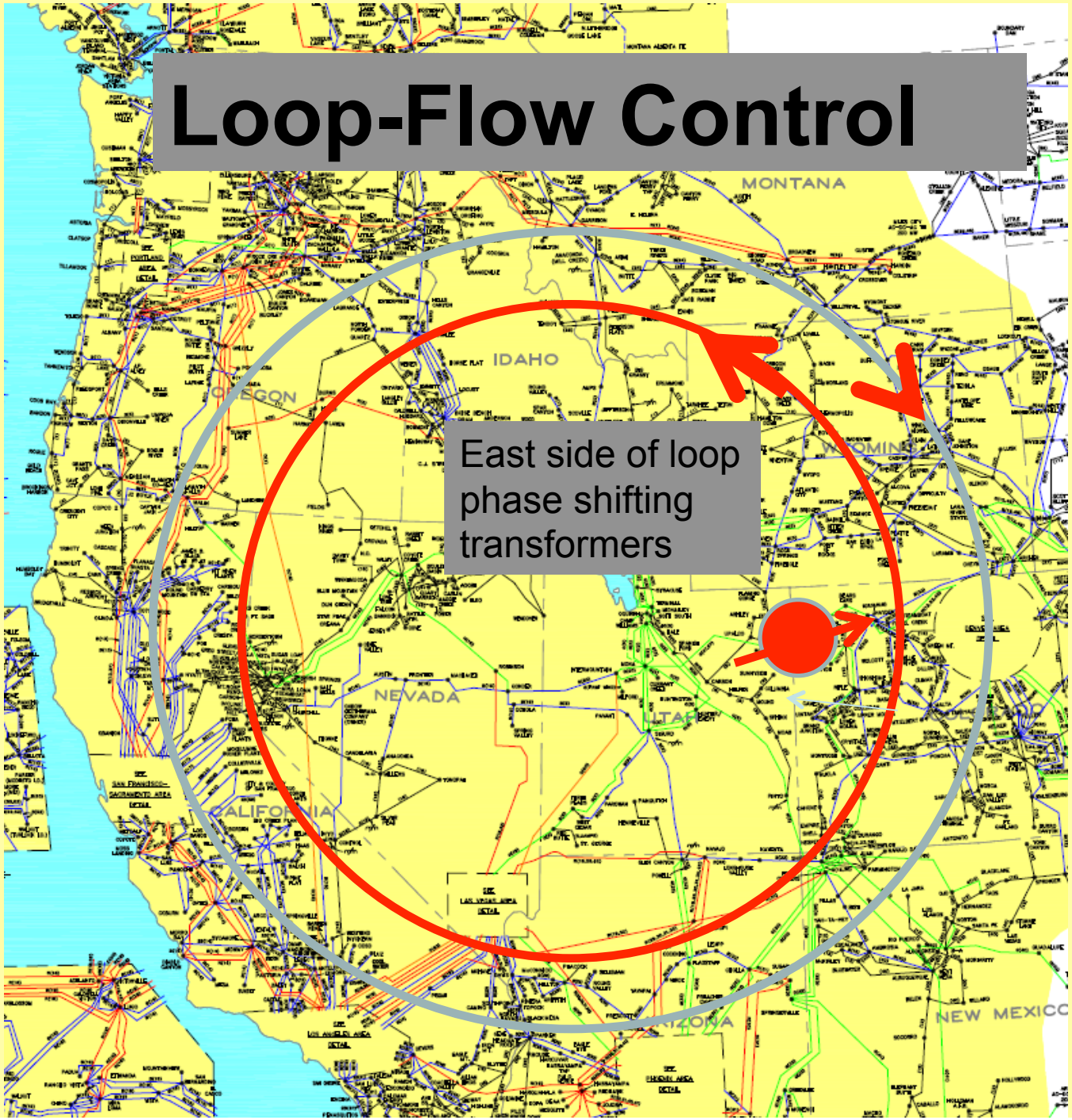
Pacific HVDC Intertie Historical Flow Controls

- Initially commissioned at 1400 MW the line went through current and voltage upgrades to the present 3100 MW.
- Celilo – Sylmar Controls Used
  - HVDC line fast ramping for AC Intertie line outages to shift loading to HVDC.
  - HVDC modulation for N/S system oscillation damping.

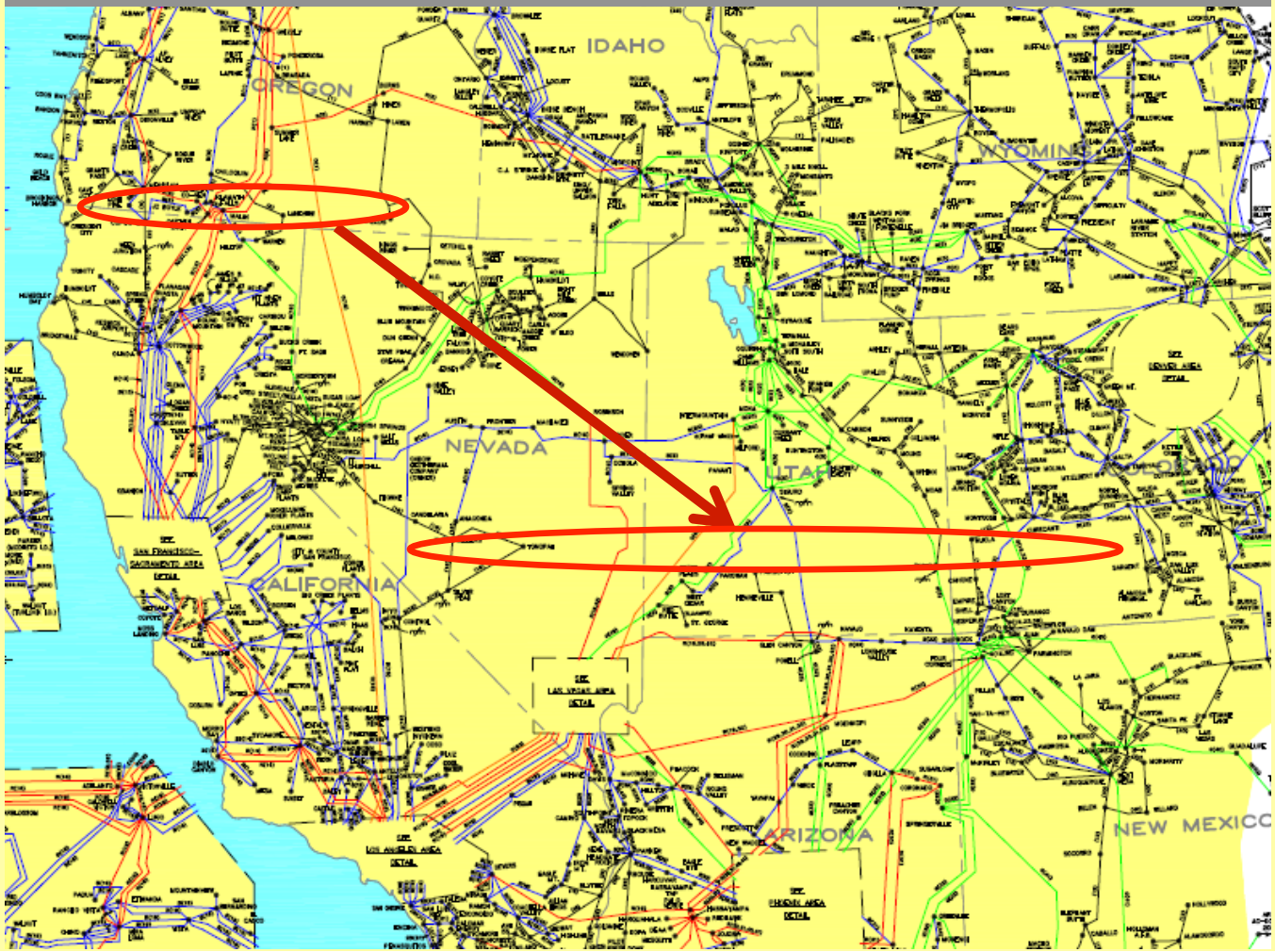
HVDC Interties



Loop-Flow Control



NE/SE Separation Scheme for Controlled Islanding



Slatt TCSC

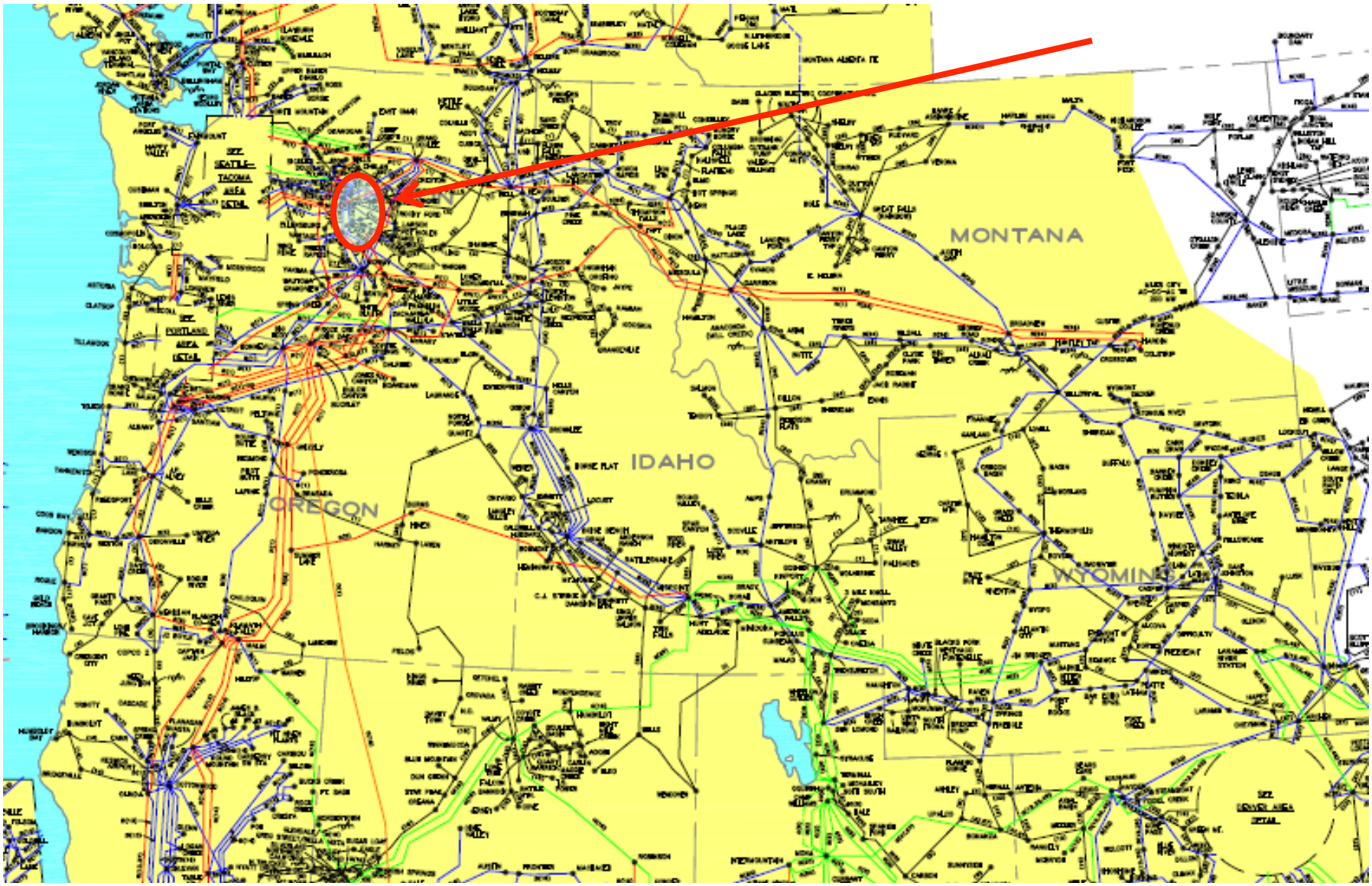
- 500 kV TCSC commissioned 1995
- 2900 A, 9.2 Ohm (cont.), 202 MVAR
- Demonstrate SSR mitigation
- Demonstrate modulation control
- Demonstrate GE design

Excellent control flexibility with high compensation levels provided by SSR mitigation.

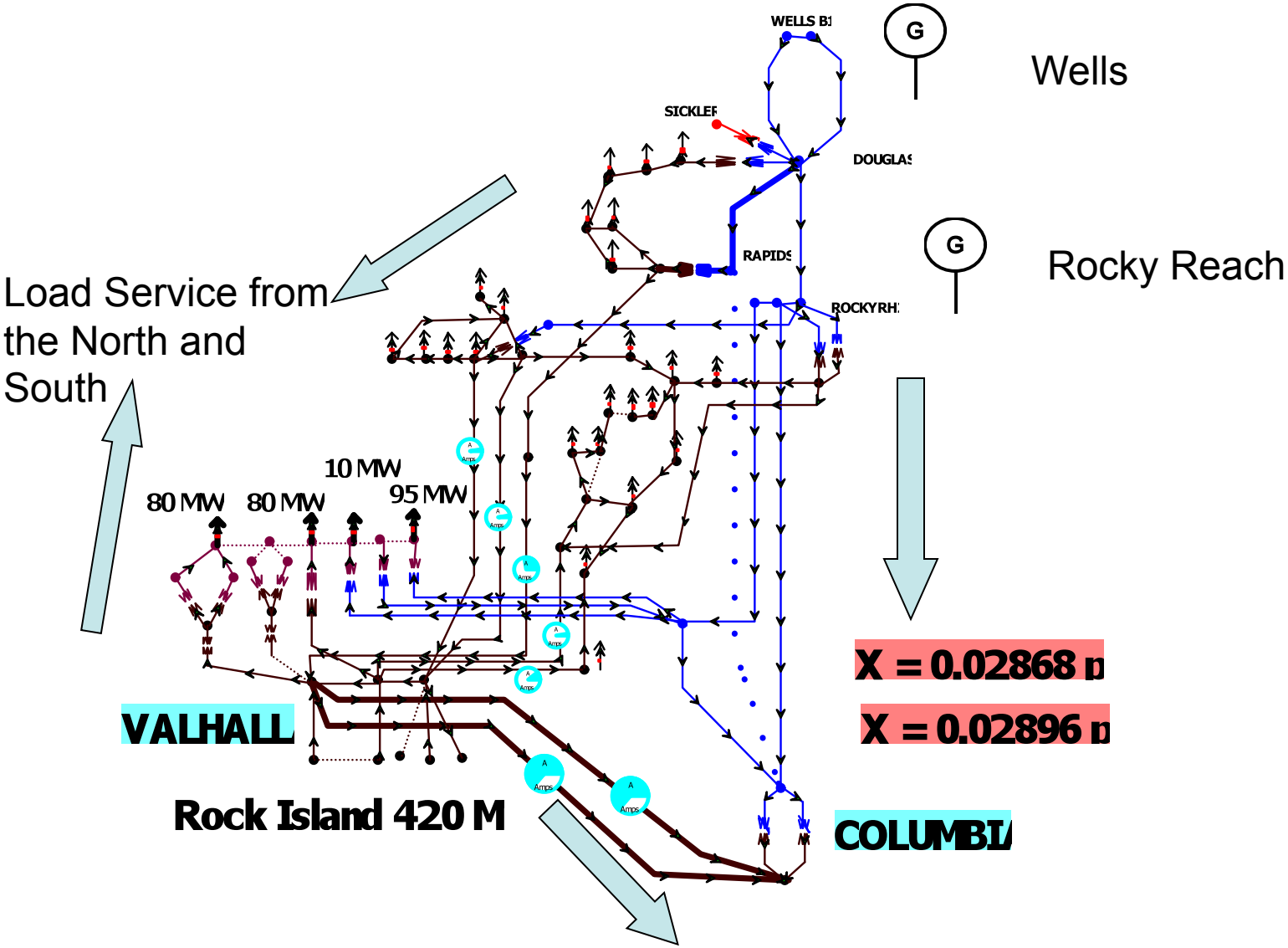
BPA Power Flow Control Project (TI 282)

Eric Heredia
Grid Transformation March 20, 2013

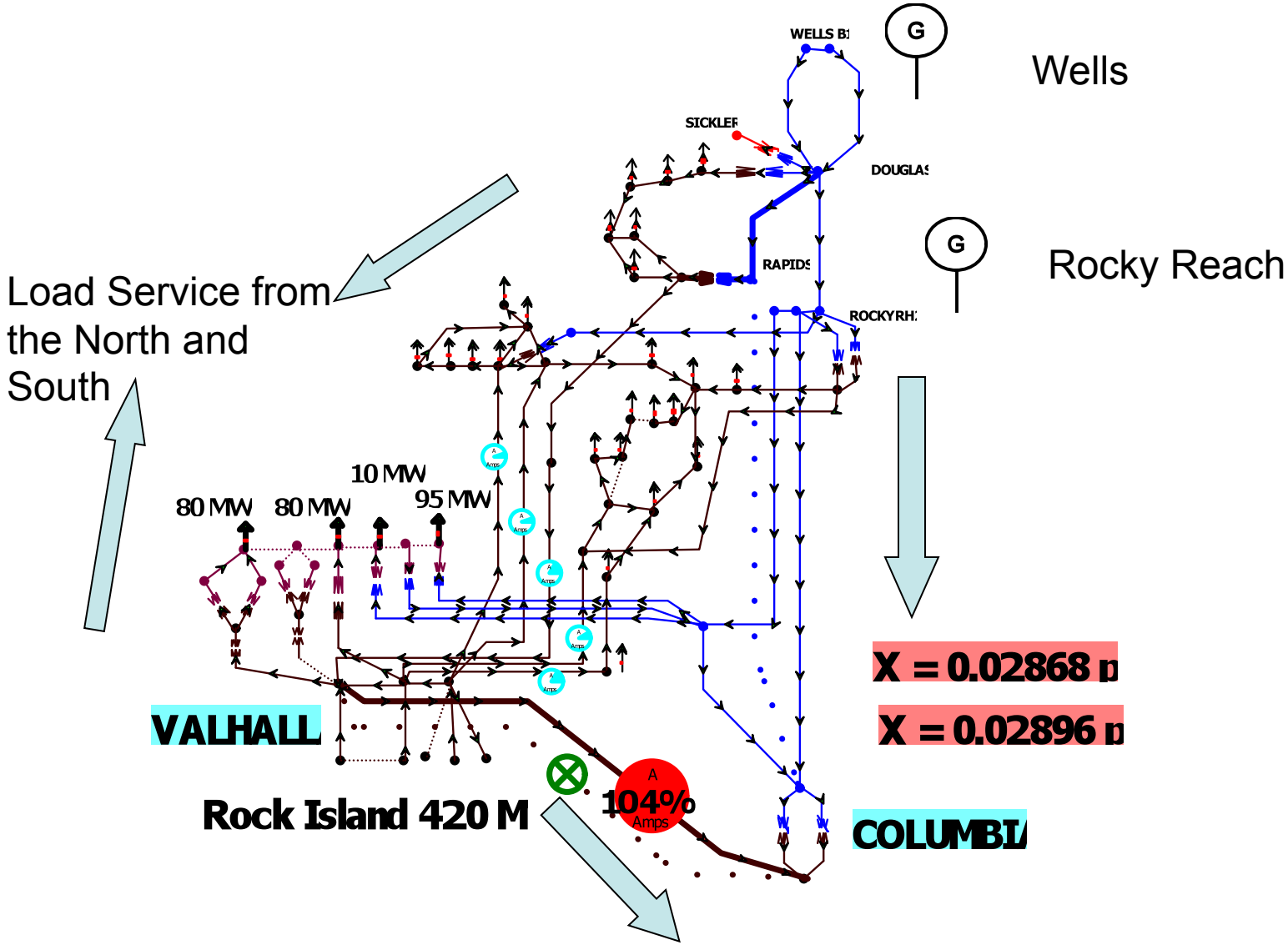
Columbia-Valhalla 115 kV



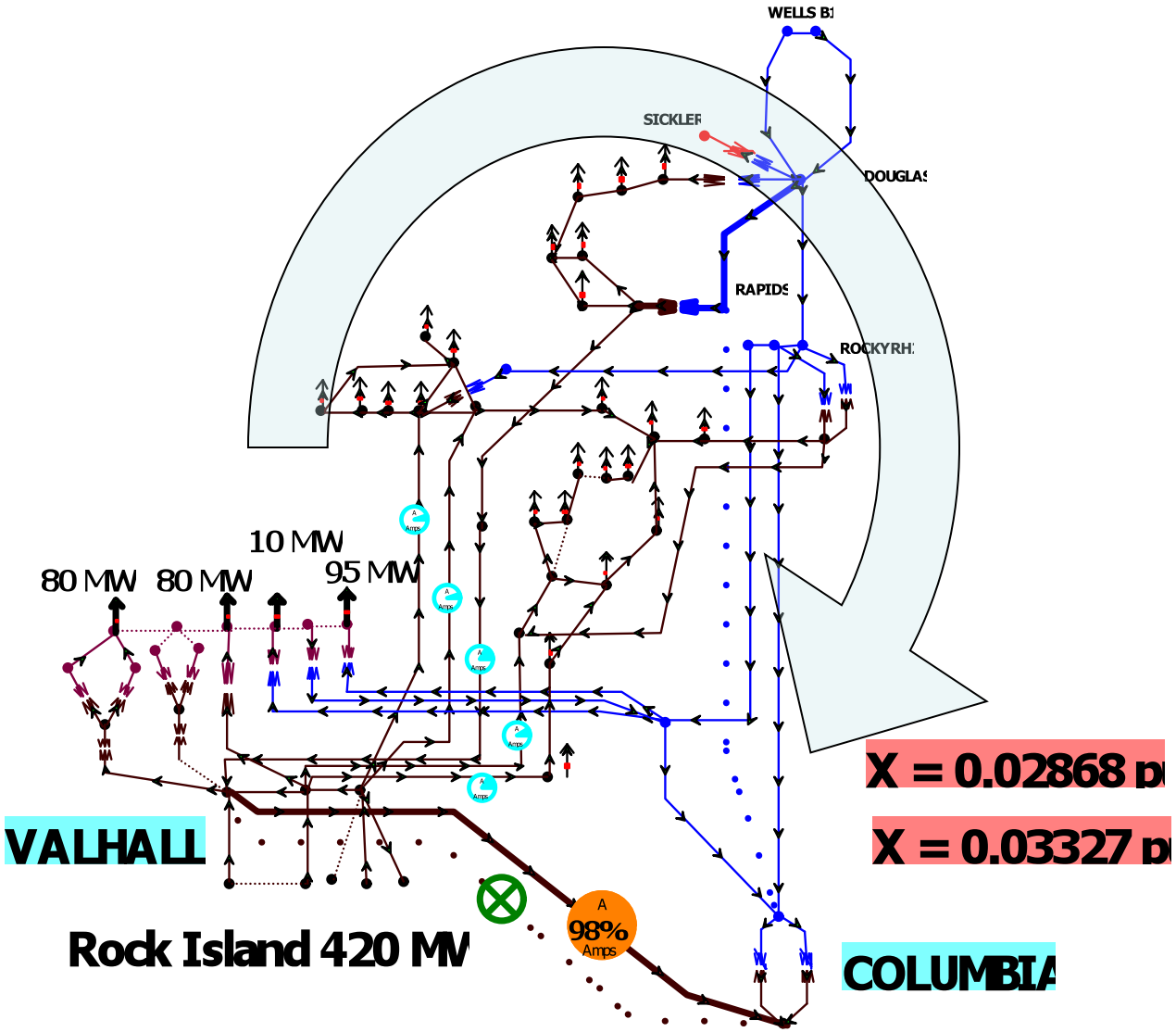
All Lines in Service



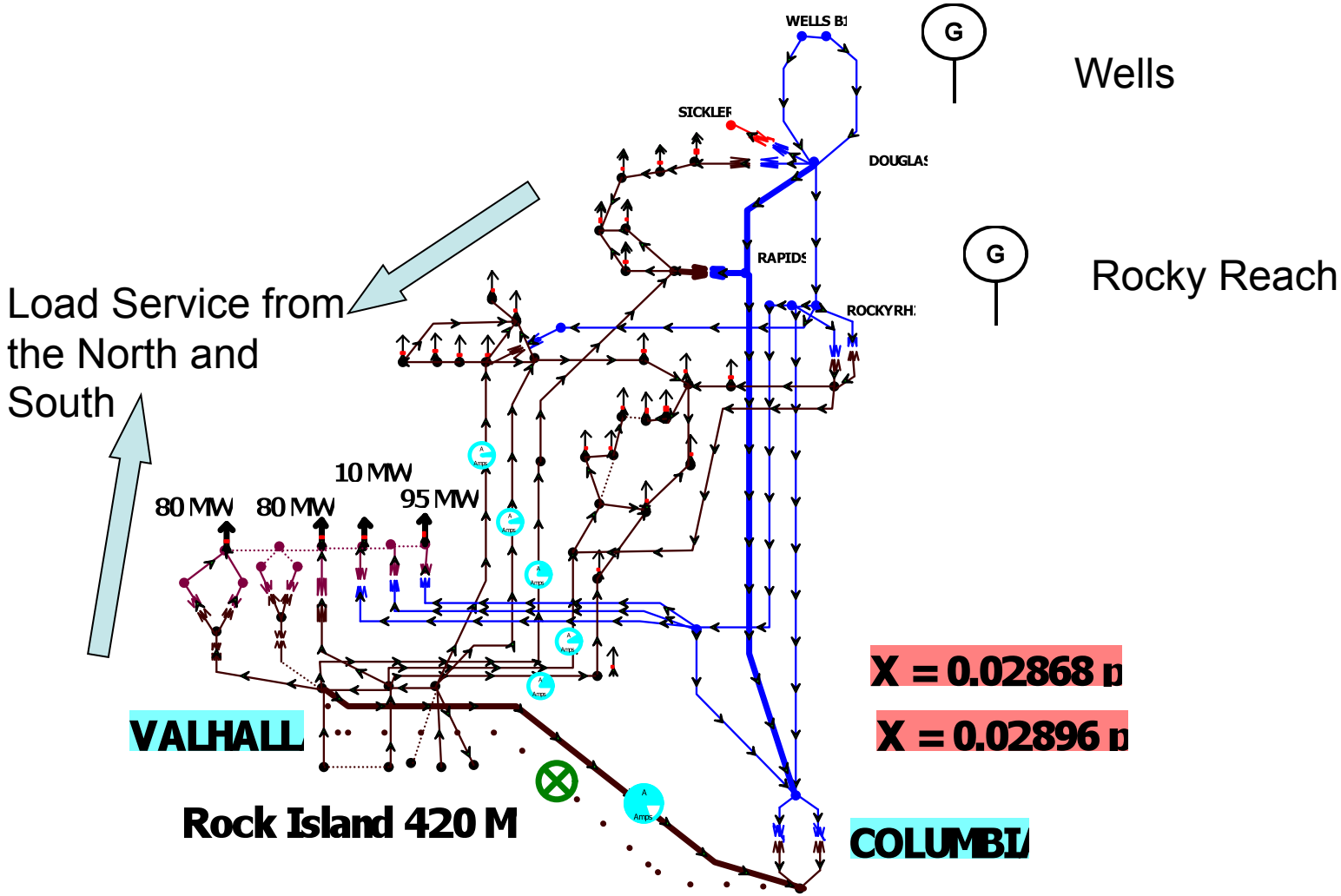
N-1: Loss of a Columbia Valhalla 115 kV Line



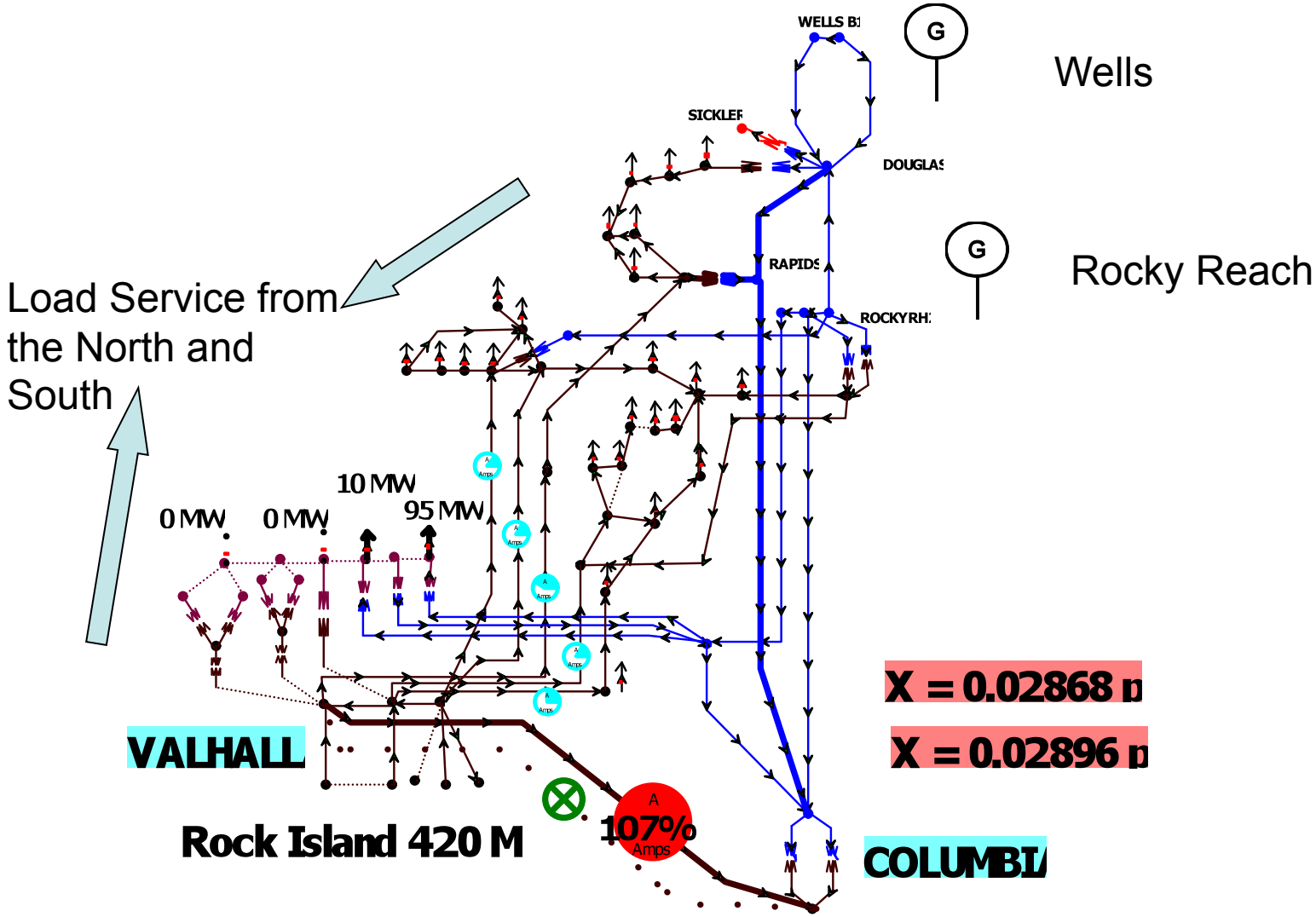
Power Flow Control To Mitigate the Overload



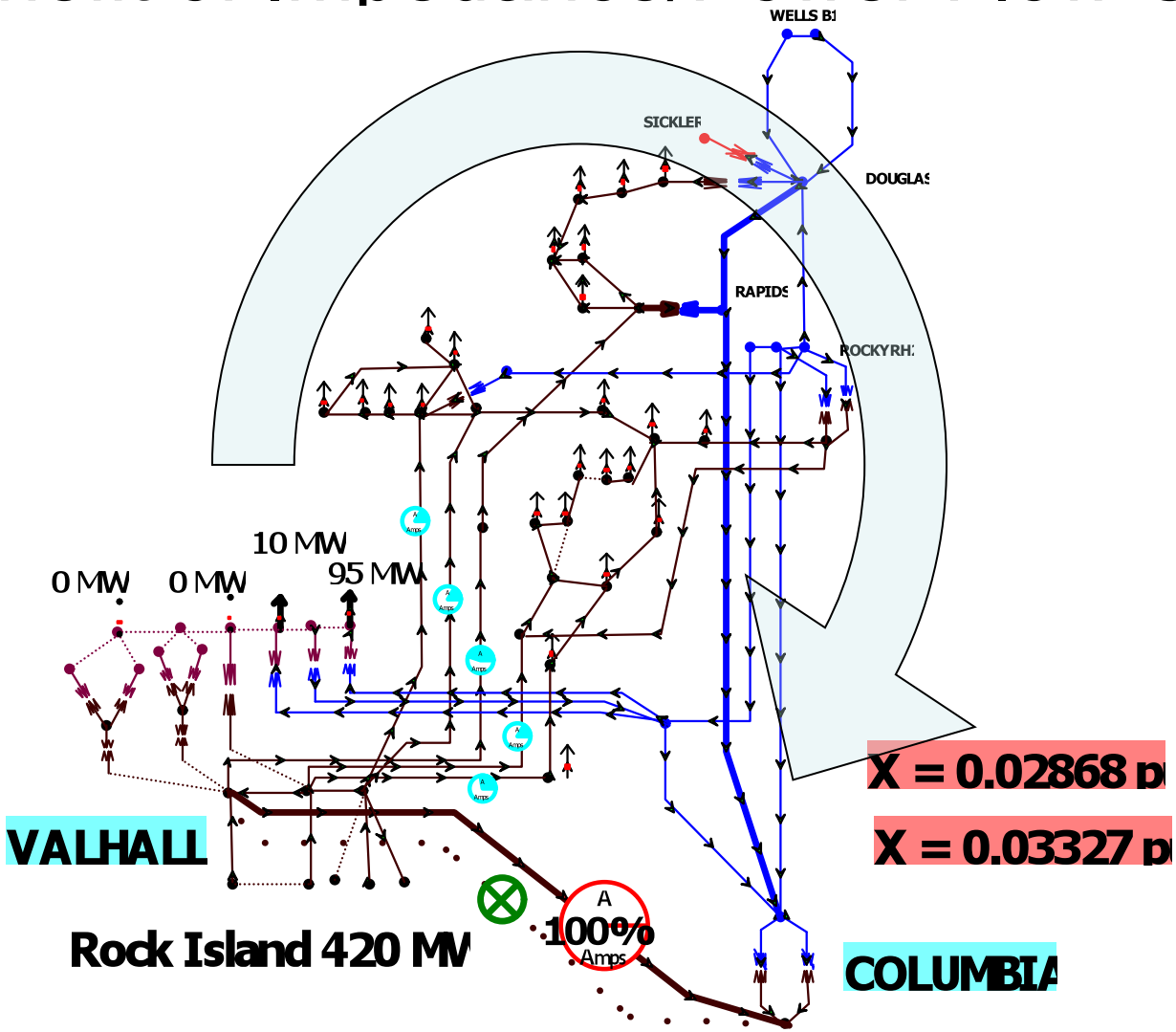
The Improvements with the new 230 kV Line



Impact of the Industrial Load Changes

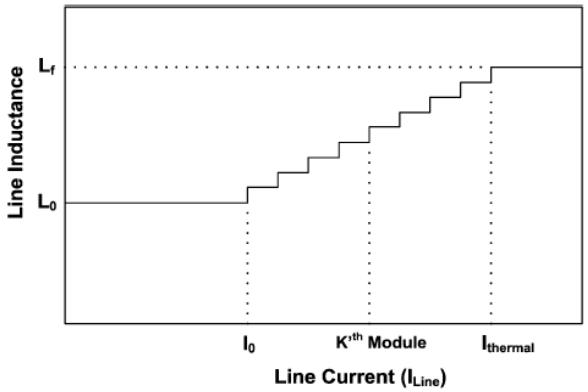


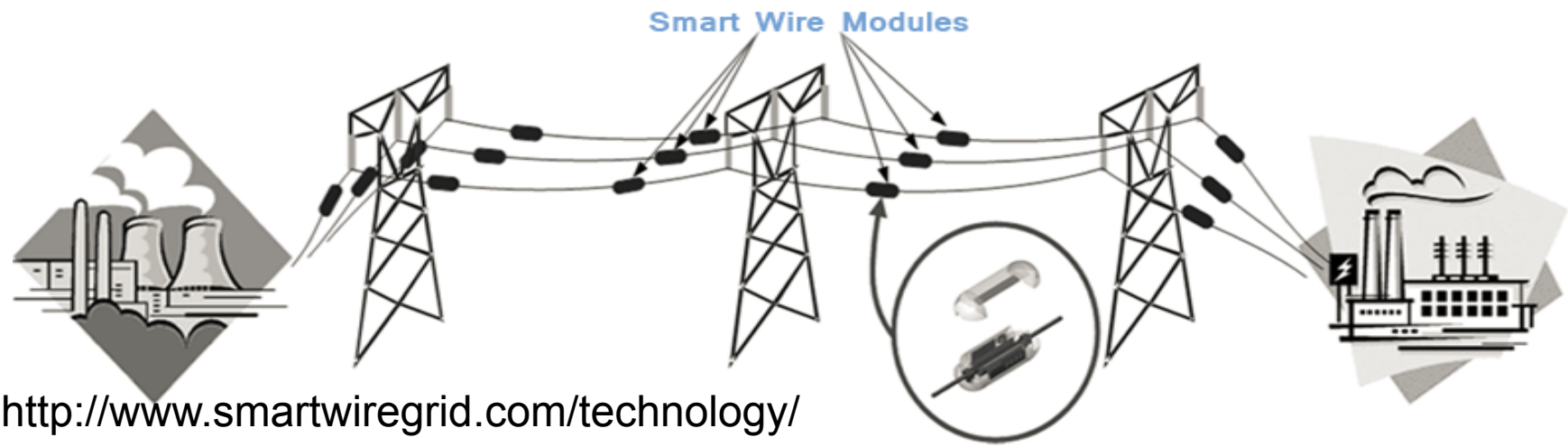
Benefit of Impedance/Power Flow Control



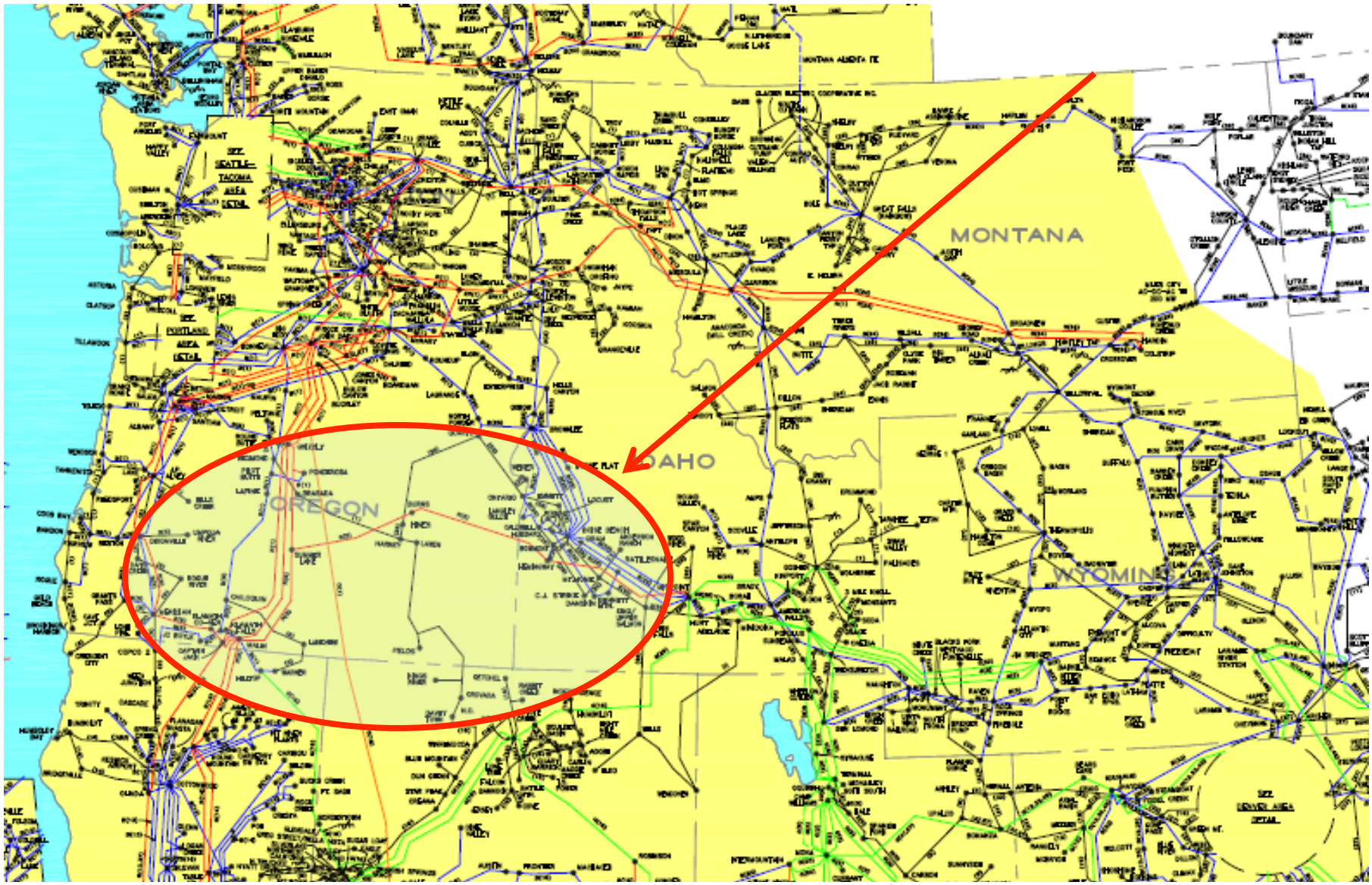
Phase 1 Studies – Columbia-Valhalla 115 kV

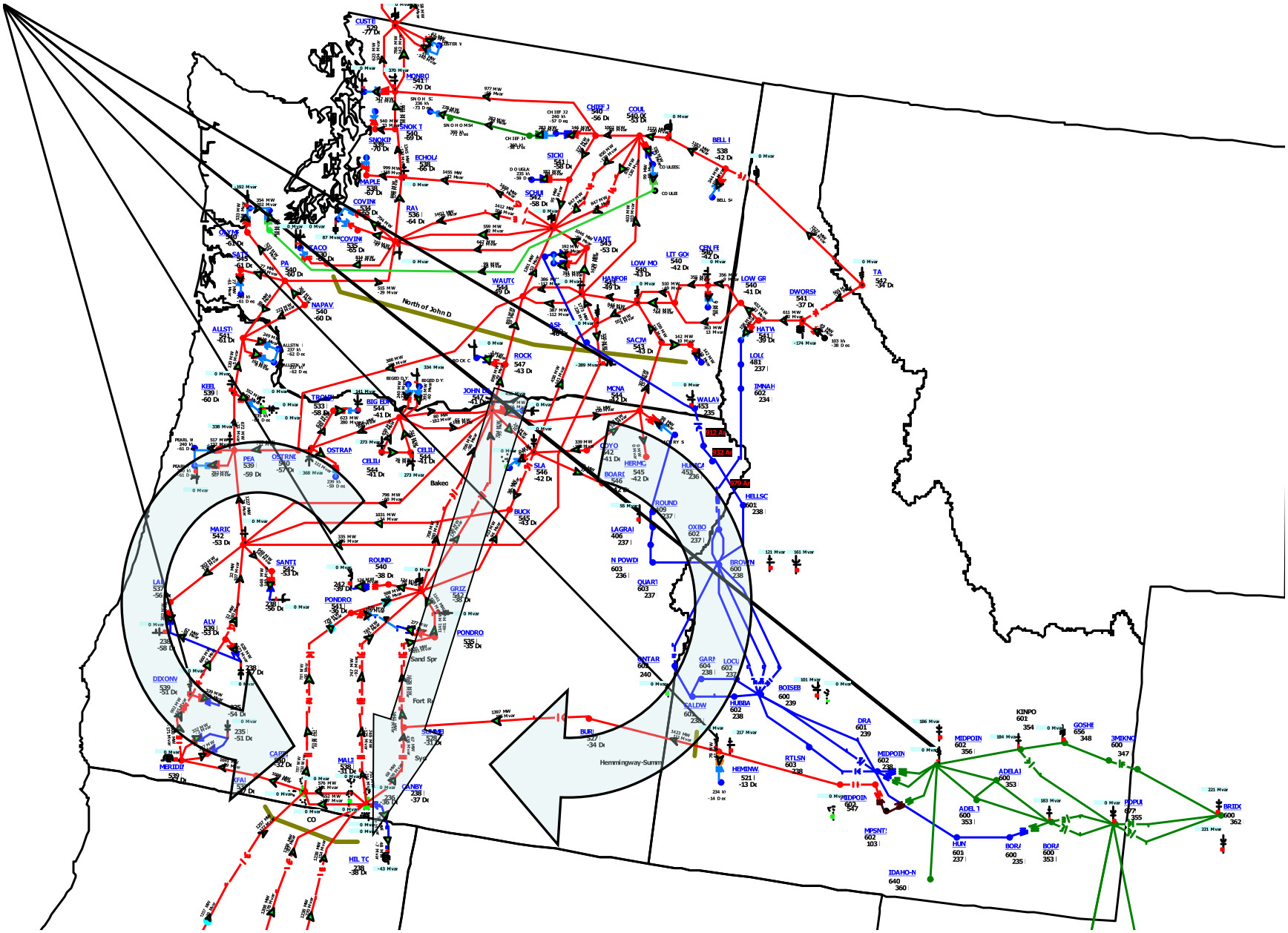
- Investigate a Power Flow Control Solutions
  - Switchable Series Inductors
  - Smart Wire Models – ideal test area
- The solution must be a better value than the construction of a third line for $5 million

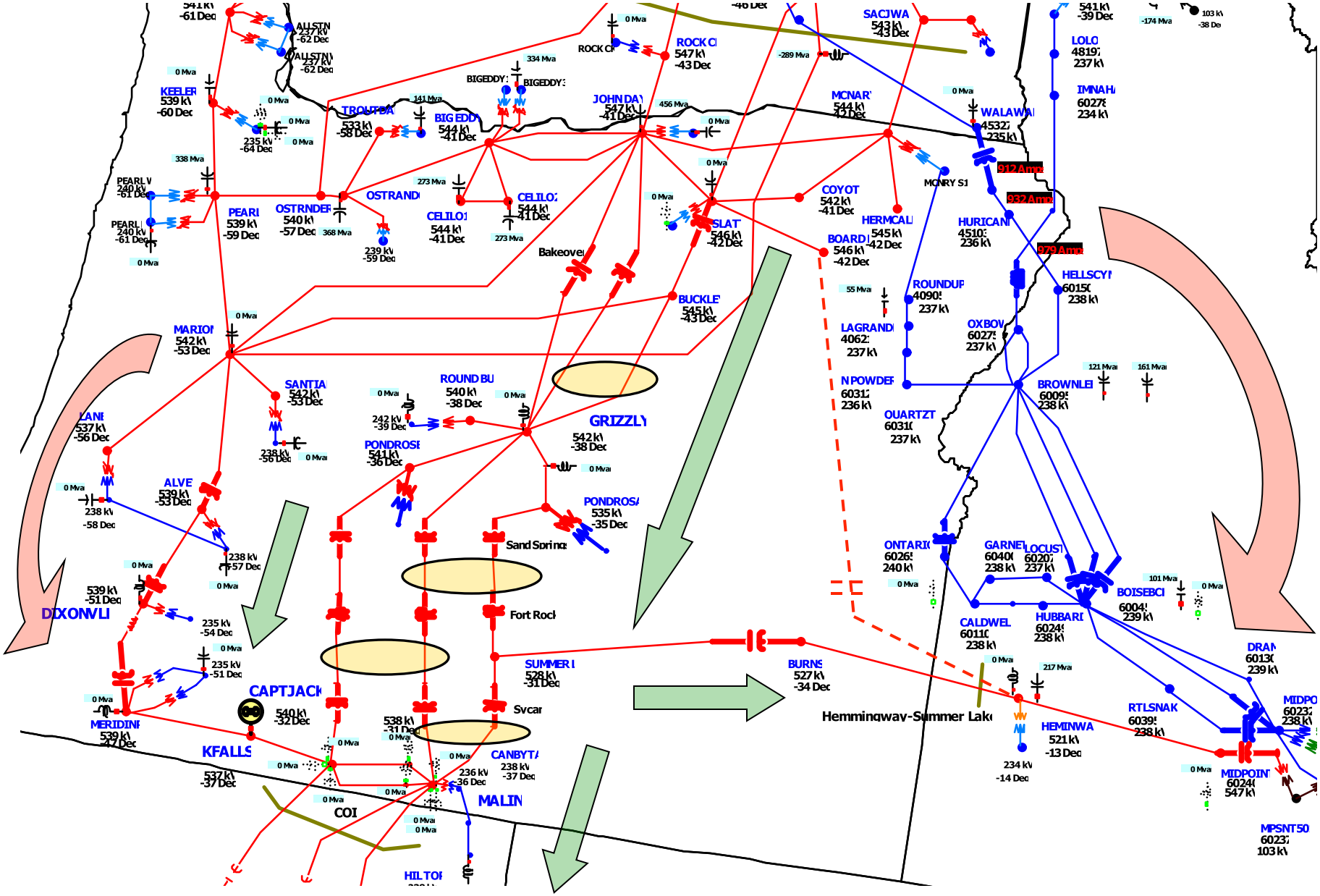




http://www.smartwiregrid.com/technology/


MONTANA
IDAHO
OREGON
WYOMING


North of John D
Hemmingway-Summ
Fort R
Sand Spr
Baker
CO

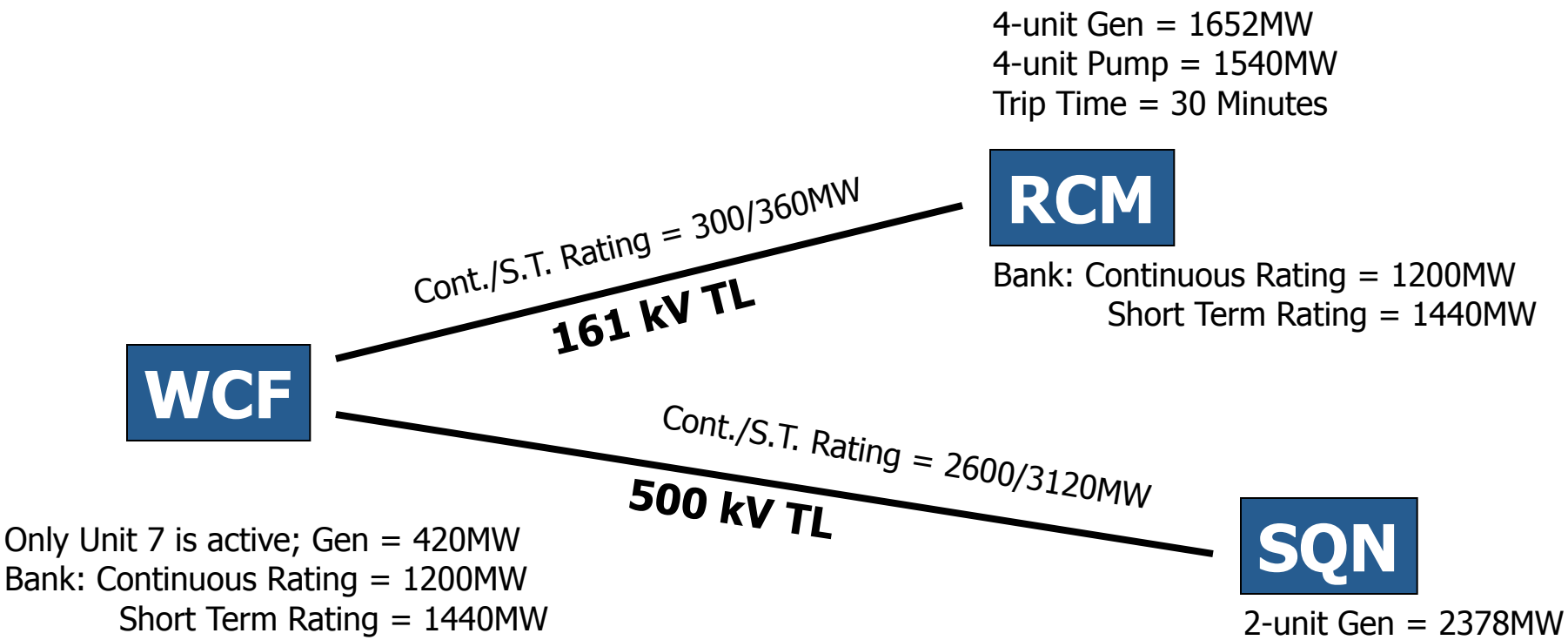

ALSTN
237 kV
-62 Deg
KEELER
539 kV
-60 Deg
TROUTDA
533 kV
-58 Deg
BIG EDDY
544 kV
-41 Deg
BIGEDDY
JOHN DAY
547 kV
-41 Deg
ROCK CK
547 kV
-43 Deg
SACJWA
543 kV
-43 Deg
MCNARY
544 kV
-42 Deg
WALAWA
LOLO
IMNAHA
PEARL
539 kV
-59 Deg
OSTRNDER
540 kV
-57 Deg
OSTRANDI
CELILO
544 kV
-41 Deg
SLAT
546 kV
-42 Deg
COYOTE
542 kV
-41 Deg
HERMCALI
545 kV
-42 Deg
BOARDMAN
546 kV
-42 Deg
MONRY S1
HURICANE
236 kV
ROUNDUP
237 kV
HELLSCYN
238 kV
Bakeover
BUCKLEY
545 kV
-43 Deg
MARION
542 kV
-53 Deg
LAGRANDE
237 kV
OXBOW
237 kV
NPOWDER
236 kV
QUARTZT
237 kV
BROWNLEE
238 kV
SANTIAM
542 kV
-53 Deg
ROUND BU
540 kV
-38 Deg
GRIZZLY
542 kV
-38 Deg
PONDROSE
541 kV
-36 Deg
PONDROSA
535 kV
-35 Deg
LANE
537 kV
-56 Deg
ALVEY
539 kV
-53 Deg
DIXONVLI
539 kV
-51 Deg
Sand Spring
Fort Rock
SUMMER L
528 kV
-31 Deg
BURNS
527 kV
-34 Deg
Hemmingway-Summer Lake
ONTARIO
240 kV
GARNET
238 kV
LOCUST
237 kV
BOISEBCI
CALDWEL
238 kV
HUBBARD
238 kV
DRAN
239 kV
RTLSNAK
238 kV
HEMINWA
521 kV
-13 Deg
MIDPOINT
547 kV
MPSNT50
103 kV
CAPTJACK
540 kV
-32 Deg
MERIDIAN
539 kV
-47 Deg
KFALLS
537 kV
-37 Deg
Svcar
CANBYTA
238 kV
-37 Deg
MALIN
COI
HILTOP
912 Amps
932 Amps
929 Amps

O&M Experience with Short Term Facility Ratings to More Fully Utilize the Grid

David (Burl) Till

Grid Transformation March 20, 2013

Bridge to Post-contingency Mitigation Using Short Term Ratings



Short Term Ratings Must be Good for at Least 30 Minutes

The Illustrative Case

ATC: at 20,000MW system load, only 3 RCM units can pump

N-1: 20,000MW only 2 units can pump

Contingencies:

Loss of: WCF 500 kV Bank
RCM 500 kV Bank
WCF-SQN 500 kV TL
WCF-RCM 161 kV TL

Consequences: for any one of these contingencies, either the WCF or RCM Bank overloads to 115%.

Without short term ratings, mitigation is pre-contingency RCM pumping derate with long duration economic loss

With short term ratings, system capability is increased until a low probability contingency occurs. Reliability is maintained, while economic loss is much reduced if it even occurs.

Barriers to use of short term ratings

How many utilities are like TVA in this respect?

Grid ratings are assigned by long term transmission planners

Information to support the confident assignment of short term ratings usually resides within the operations and maintenance world e.g., DGA analysis (for CO, CO_2) likely confirms no xfmr loss-of-life

Opportunity to enhance communications between these worlds can yield appropriate use of short term ratings to realize significantly higher use of the grid

Questions for the Panel and Group

- Have modern power flow control devices improved?
  - FACTS devices have limited market penetration. Are they to costly and complex? Do they have higher failure rates than lines, transformers, and breakers?
  - What is the reliability risk of power electronics in comparison to discrete switching with breakers?
  - What about modern phase angle regulating transformers (complex, costly, limited tapping)?
- What would make a re-dispatch market successful? Are there good examples? What concerns exist and need to be addressed?

Questions for the Panel and Group

- Radial service plans versus parallel/mesh plans:
  - What is the tradeoff in terms of risks and cost/benefit? Can existing systems be reconfigured to reduce parallel flows that limit main grid transfers? Can radial loops and radial feeds be designed without major impacts to load service reliability?
- Automatic sectionalizing, generation dropping, load shedding, or demand response:
  - What is the limit? Should load be used? What are the risks?
- Improved real time state awareness: thermal limits, reactive margins, and stability boundaries.
  - What is being developed? What do we want to have in the future?

Next Steps

- Does anything stand out as “best ideas” to improve grid controllability improving the operational flexibility and transmission capability?
- Are there experiences and practices that we can share to help others improve?
- Are there areas where we can collaborate to develop a more controllable network in the future?