NORTHERN TIER
TRANSMISSION GROUP

National Electric Transmission Congestion Study Workshop
Panel II – Industry

December 13, 2011
Portland Airport Sheraton Hotel

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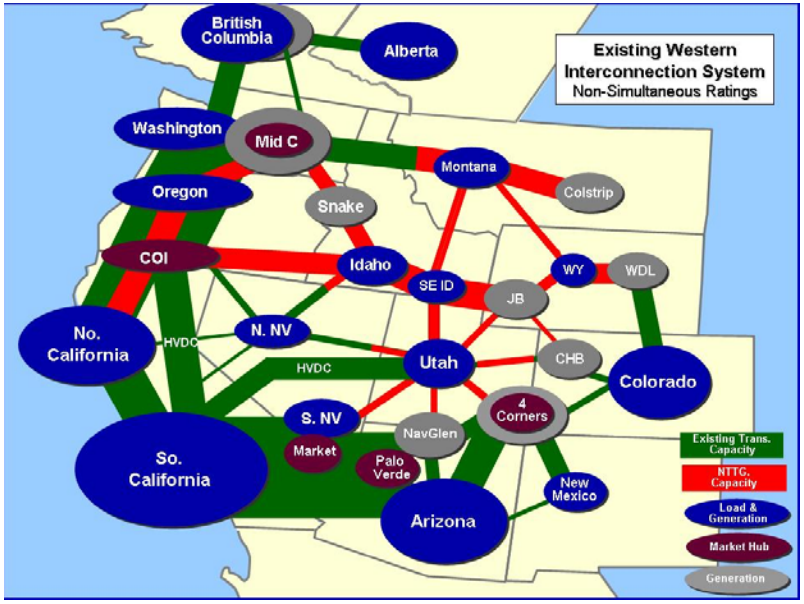
Vice Chair - WECC TEPPC

"To ensure efficient, effective, coordinated use & expansion of the members' transmission systems
in the Western Interconnection
to best meet the needs of customers & stakeholders."

NTTG Transmission system



NTTG System:

- Connecting eastern generation to load centers across the Western Interconnection
- Hydro – thermal integration & coordination
- Long EHV transmission to deliver energy from dedicated coal
- Connects high quality renewable zones to coastal load areas, California, & Desert Southwest

A Brief history

- 70's – 80's:
  - Coastal units fired by oil, Oil embargo,
  - Reliance on oil & policy to reduce consumption
  - Widely varying prices,
  - Congestion - system wasn't designed for long dist exports
- Mid 80's Transfer Study
  - Transmission expansion to reduce oil use & congestion
- Eastern coal fired generation build out during 80's
  - Long distant transmission to deliver energy
  - Capacity provided by coastal hydro & thermals
  - Long EHV transmission dedicated to coal - just fits
- Coastal oil units converted to gas
- Disaggregation of G,T,D
- 90's: High gas prices & Increased long dist transfers
- Order 2000 - Markets & RTOs
- 8-2001 Report - WGA "Conceptual Plans for Electricity Transmission in the West"
  - Plan adequate Transmission for competitive markets
  - SSG-WI & WECC Economic Studies
- Present:
  - Renewable build outs with zero marginal cost & short installation lead times
  - Transmission costs & development times growing
    - Times two to three times longer than renewables
  - Coal units cycling

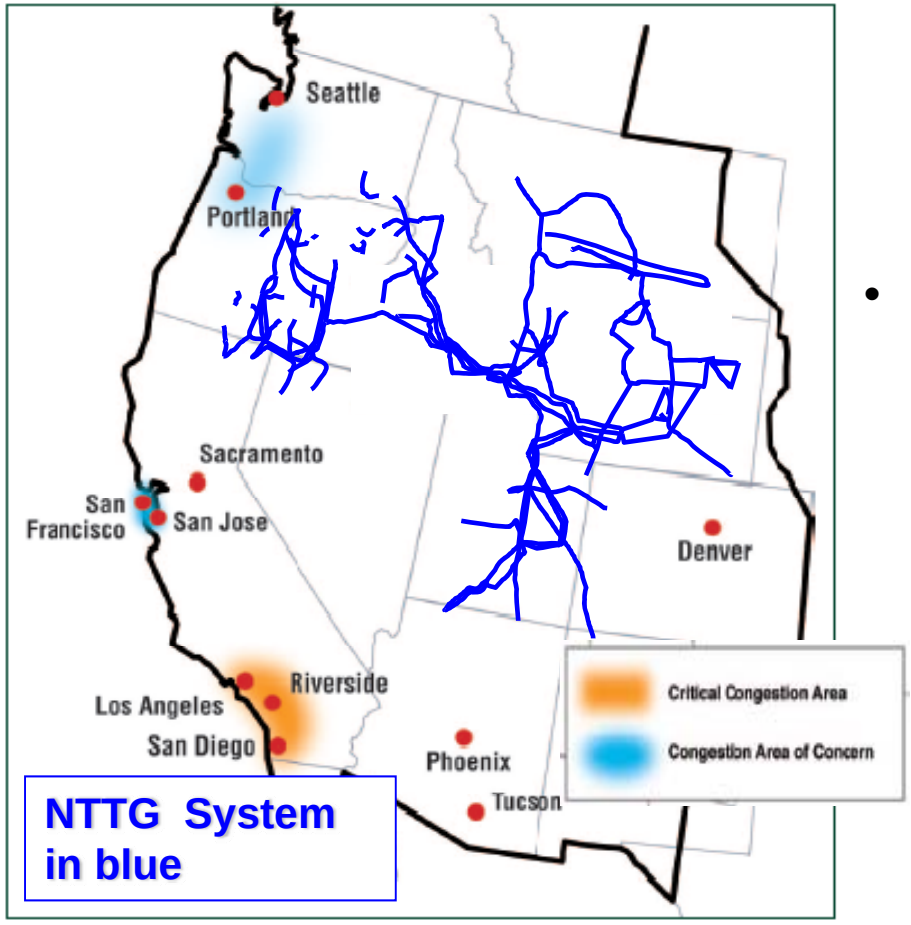
Barriers to Transmission Development in NTTG

- **Transmission takes long time to plan & build**
  - Long expensive lines
  - Large investment & risk
  - Customer density within footprint
- **Expansion by TPs requires long term commitments from customers**
  - Transmission Service commitments
  - Equity participation
  - Generator Interconnect Agreements
- **Reliability is typically the driver for transmission expansion**
  - To provide required, committed transmission service
  - Long term commitment from customers required for transmission service
- **Significant congestion savings by itself usually isn't enough to justify long expensive new transmission**
  - Marginal generation is gas fired & locational prices don't differ as widely. Coal generation still less than gas and wants to displace gas.
- **Uncertainty of resource needs of Importing/Exporting regions delaying decisions by customers to commit to transmission**
  - Provincial development,
  - Tax credit risks
  - Policies
- **Resource commitment timing needs to align with transmission expansion processes**
  - Resource policies, resource expansion planning, development, customer requirements
  - Too risky to "build [transmission] & they will come"
- **Developing issues include:**
  - Reserves & balancing amount & locations
  - Dynamic Transfer Capacity Limits of Transmission

DOE 2009 Congestion Study:

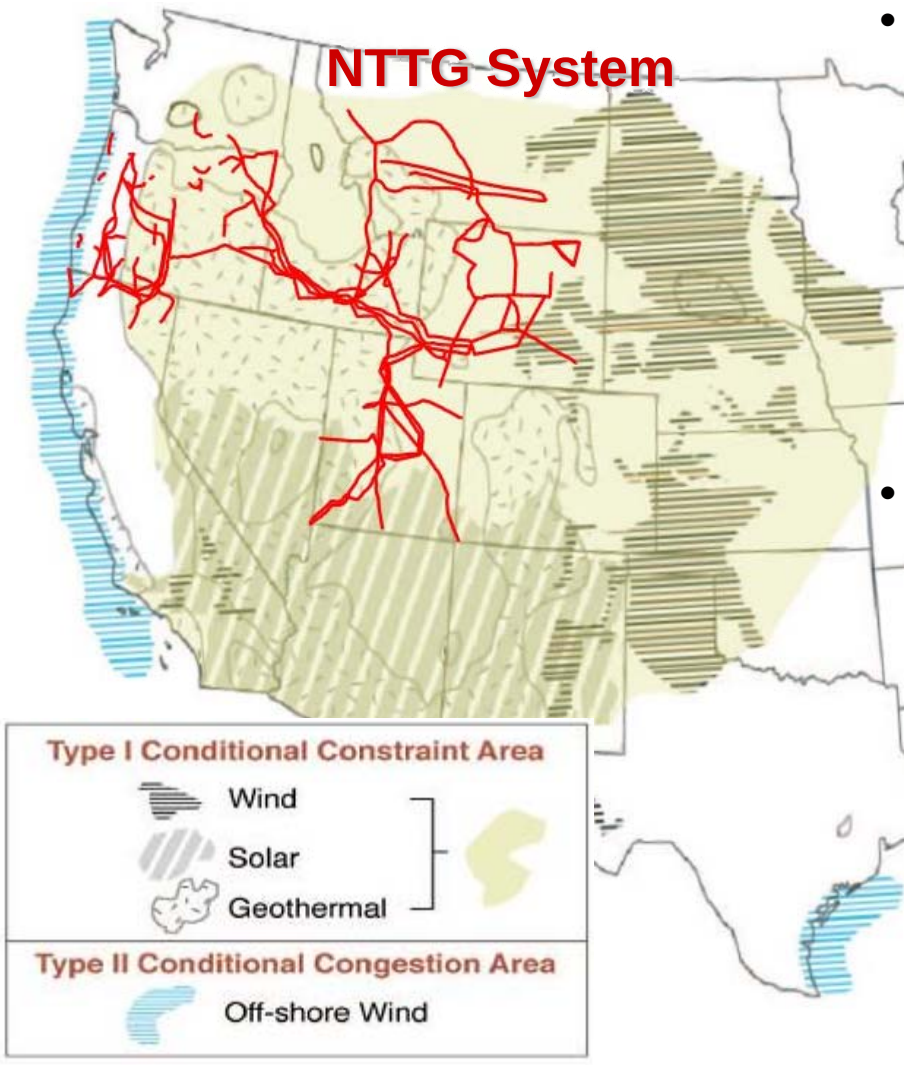
Congestion Areas – "Critical" & "Of Concern"

Figure ES-3. 2009 Congestion Areas in the Western Interconnection



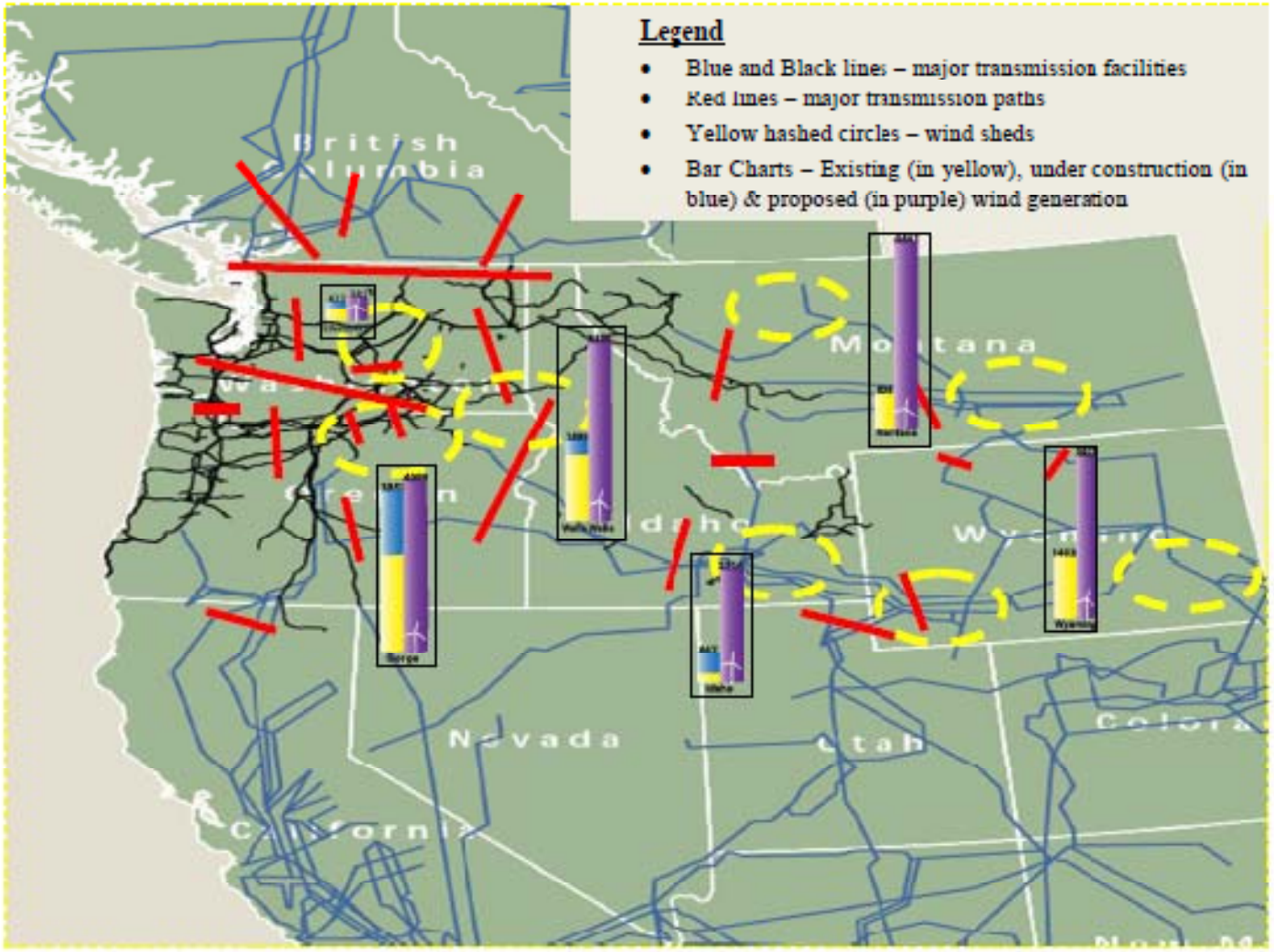
- **Critical Congestion Areas in 2009**
  - Generally agree the 2009 studies were representative
  - NTTG not directly involved in Seattle to Portland "Area of concern"
    - But, planned new NTTG transmission on east side could help relieve Seattle to Portland congestion
- **Potential New Congestion Areas:** Conditional Congestion becoming actual
  - Eastern Oregon & Washington Wind development since 2009 Study causing:
    - Additional congestion into NW coastal load areas
    - Hydro Op issues & Environmental Re-Dispatch
  - Wind development in Wyo, Montana & Idaho
    - Cycling & operating problems with Thermals
    - Fast acting Thermals & Balancing
  - Transmission under development for reliable service to commitments:
    - Portland & Willamette Valley
    - Northern & SW Utah
    - Central Idaho
  - Dynamic Transfer Capacity Limits

DOE 2009 Congestion Study Conditional Congestion



- Some indicated Type I Conditional Congested paths are becoming congested:
  - Some renewables have committed & transmission developed:
    - Wyoming, Idaho & Montana WREZ zones
    - Additional east side generation additions
  - Transmission being added to fix Conditional Firm & facilitate service for committed TSRs
- NTTG 2010-2011 Ten Year Plan Study, Report, & scenarios
  - Planned “Foundation” transmission will handle base case L&R growth
  - If significant additional renewable development occurs during the 10 year planning horizon (or longer) new large transmission additions will be required
    - To deliver transmission service reliably & without chronic congestion

Renewable Generation Potential & Conditional Congestion



Factors Effecting Customer Decisions for Future Expansion

- Resource Requirements & IRPs
- Legislative & Policy
  - RPS requirements
    - Exponential trajectory of variable renewable development
    - Timing of resource additions relative to transmission expansion
  - DSM
  - Land Use, ROW, permitting restrictions
  - Clean Air & Green House Gas requirements
  - Renewable Generation Tax Credits
- California internal resource development & legislation
  - Uncertainty of long term California requirements & import/exports
    - Out of state restrictions of imports
    - RECs
  - Solar build out
- Growing amount of Renewables & Integration of Variable generation - reserves/balancing
    - Flexible Reserves required
    - Location of & responsibility for reserves
    - Within Hour Scheduling & Market development
    - Transmission implications – Dynamic Transfers and Capacity

Congestion & Transmission Use Studies Underway

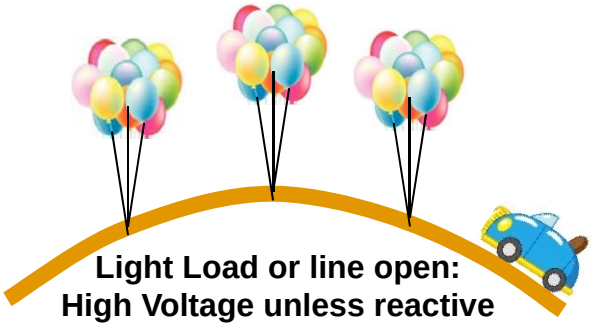
- 2012 DOE Study should use as much ongoing Western Interconnection analysis as possible
  - 2009 DOE Congestion Study utilized 2007 TEPPC Analysis to large extent
- New congestion data & studies available to 2012 DOE Study include:
  - June 24, 2010 HWG Western Interconnection Transmission Path Utilization Report
    - 2008 & 2009 data
    - Schedules & actual flows on WECC Rated Paths
  - 2010-2011 HWG Analysis & Report in progress
  - RTEP 10 Year Plan & related analysis
    - Economic Study Analysis Results – Highly Utilized
      - » Path 8 (Montana to NW)
      - » Pacific Intertie
    - Foundation list & Common Case Transmission Assumptions
  - NTTG Transmission Use Committee ATC Data & Report
    http://nttg.biz/site/index.php?option=com_content&task=blogsection&id=10&Itemid=57
    http://nttg.biz/site/index.php?option=com_docman&task=cat_view&gid=273&Itemid=31
  - NTTG 10 Year Plan Report
    http://nttg.biz/site/index.php?option=com_docman&task=cat_view&gid=308&Itemid=31
  - New cycle NTTG Economic Study analysis

Other Areas of 2012 Focus

The 2012 Congestion Study could additionally focus on the following since they effect proper analysis of congestion and transmission need:

- Modeling and Analysis: Need for 5 minute interval production cost modeling to advance analysis of within hour variability
- Location and amount of reserves required
  - Must run fast acting thermal generation
  - Primary and secondary reserves
- Dynamic Transfer Capacity
  - Effects of transmission Transfer Variability Limits (TVLs) on moving balancing and reserves across systems
- Coal unit cycling
- Need for storage
- Gas pipeline system implications

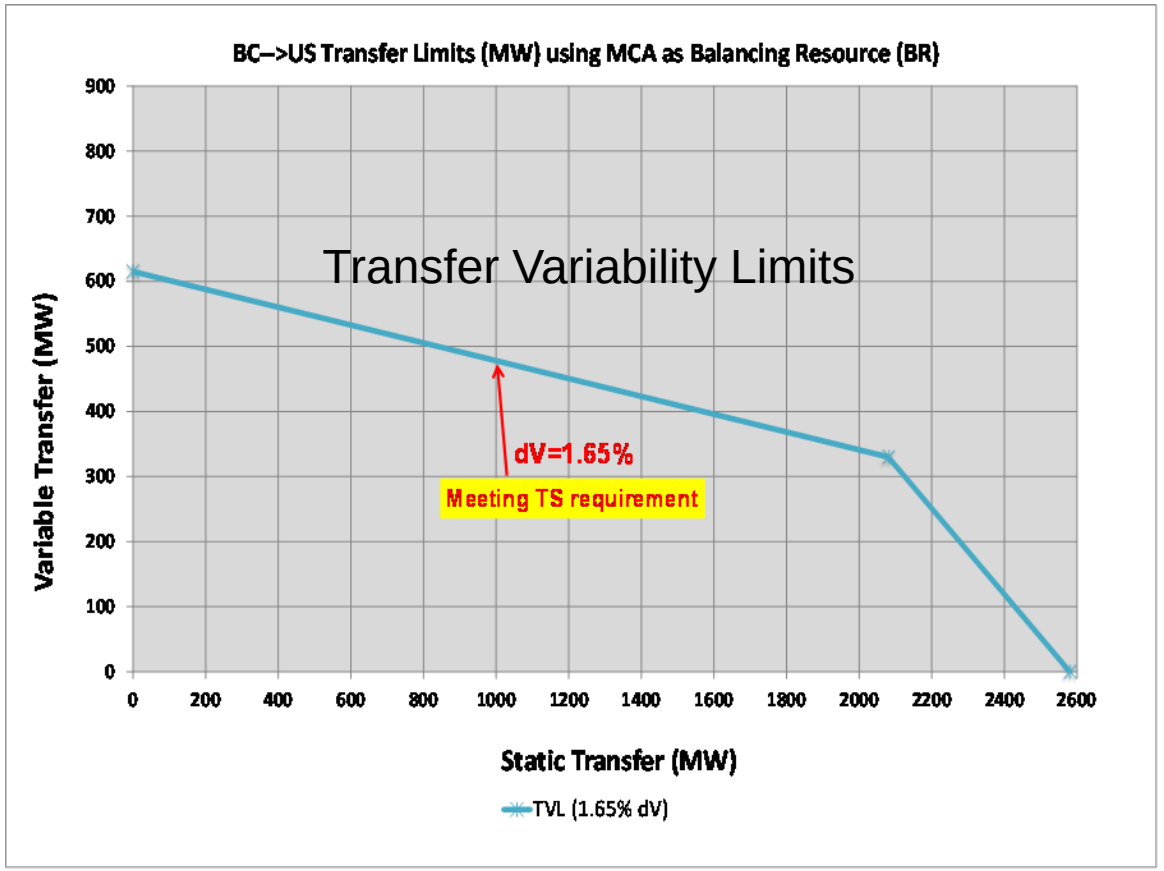
Dynamic Transfer Capacity



Light Load or line open: High Voltage unless reactive switched off

Maximum TTC, Transmission "Tuned"

Low Voltage: Without added Reactive – could be a voltage collapse



- Static Transfers are:
  - Transfers that remain constant over scheduling interval between system readjustment and operator tuning
  - Scheduling interval traditionally 1 hour in NW
- Variable Transfers are:
  - Power transfers that vary during the schedule interval (freq & mag)

Congestion Metrics

- Not all highly loaded paths are congested
  - Congestion & use analysis requires careful attention & use of metrics
- June 24, 2010 HAWG Western Interconnection Transmission Path Utilization Report – Schedules & Actual Flows
  - **6.1.Path Usage:** Paths with the most heavy usage/congestion based on year 2009 historical **flow & schedule** data, are the following, listed in order of most congested:
    1. IPP DC Line
    2. Bridger West
    3. Southwest of Four Corners
    4. West of Borah
    5. Montana to Northwest
    6. East of Colorado River
    7. Path C
    8. TOT 2A
    9. Northwest to Canada
    10. Alberta to BC

Paths fully subscribed with dedicated generation – Usage designed to be high Firm transmission rights used

- Designed loading versus Chronic Congestion
  - Highly loaded paths should be more closely analyzed before conclusions
- Metric to measure Wind Spill & Coal Cycling

Economic & Congestion Studies in NTTG

- Economic Study Products
  - Bookends future dispatch patterns
    - Optimal dispatch (perfect market) - flows constrained by transmission path limits based on Reliability Standards
    - Flow based transmission analysis– distribution factor
      - No firm or non-firm or commercial contractual restrictions applied (since not known for future deals)
    - Chronological Hourly Path flows & dispatch (idealized) over future year
    - Congestion – number of hours when dispatch might be dispatched out of merit order or non-optimal because of transmission limits
    - Hours of high loading levels near transfer limits: U75, 90, 99
      - Could give indication of relative hours of limited ATC or operation risk
    - Relative differences in performance & generic locational production costs
      - Not a forecast of prices
      - Used for comparative analysis
      - Not detailed enough for RTO type forecasts
- Used to select stress hour dispatch to test reliability of alternatives
  - Best guess of future transmission loading patterns
    - When long term commitments aren't established & are uncertain

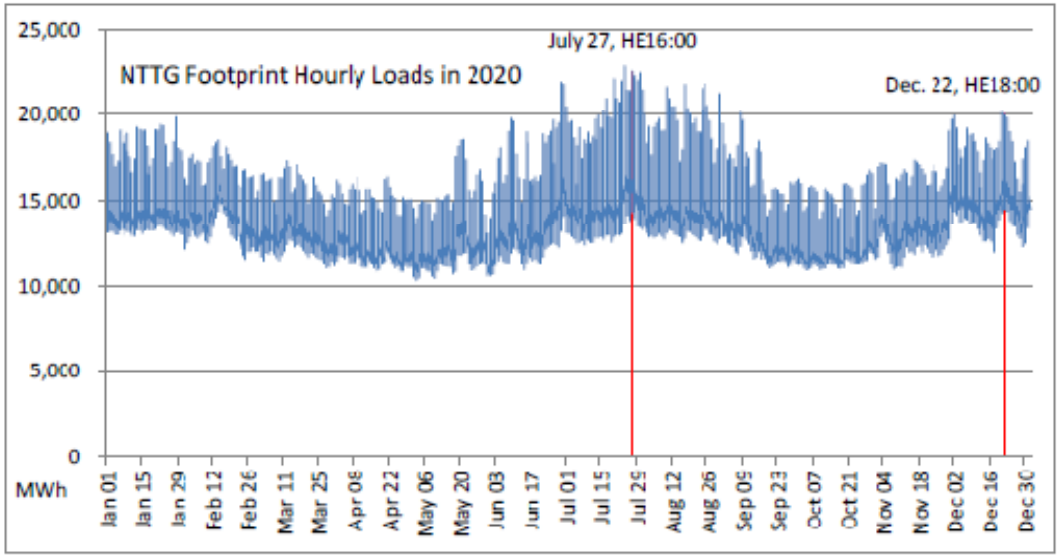
2010-11 Study & 10 Year Plan Report

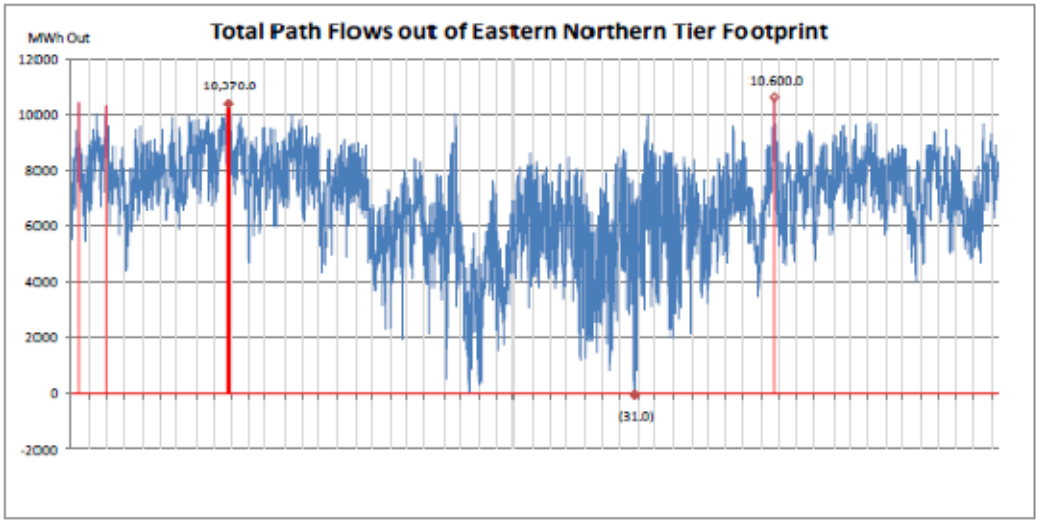
- Base Case 2020:
  - 10 Year forecast L&R NTTG requirements
  - High transmission stress level export & import hour cases tested for transmission reliability & adequacy

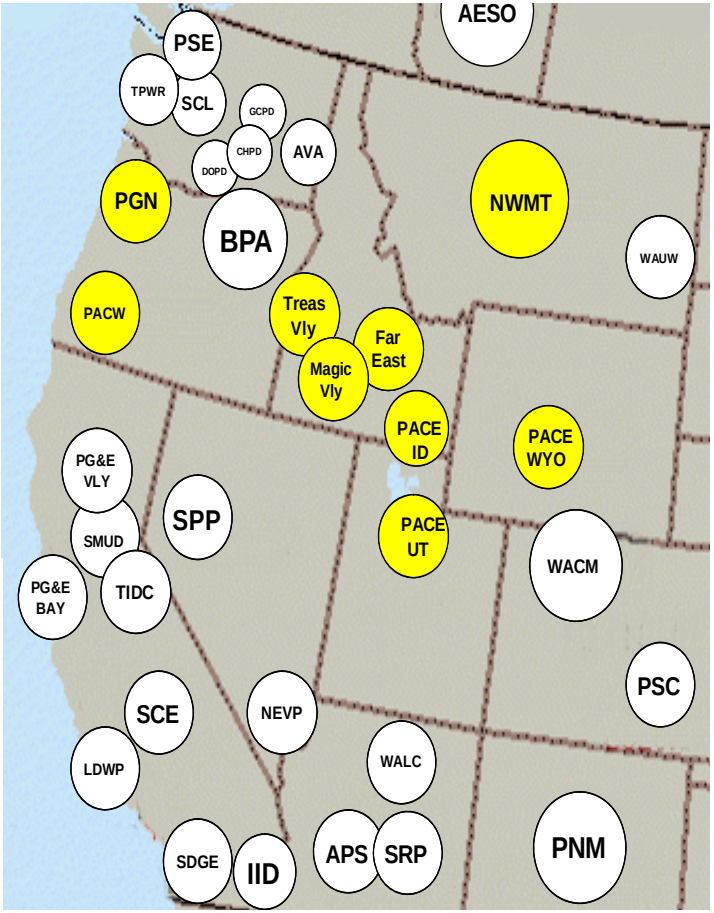
- Scenarios:
  - Source: Large Variable Generation additions in Montana & Wyoming WREZs and proposed for study by stakeholders
  - Sink: Dispatched as per production cost model into importing areas

- Planned Transmission, New & Other Alternatives evaluated
  - Reliability studies with NTTG footprint load growth & resource additions indicate reliability issues in 2020 if no new transmission is added
  - NTTG “Foundation List” additions enable NTTG 10 year requirements to be reliably met
  - New transmission required for additional wind development as per scenarios

2010-11 Study & Report: Load & Export Hours Selection

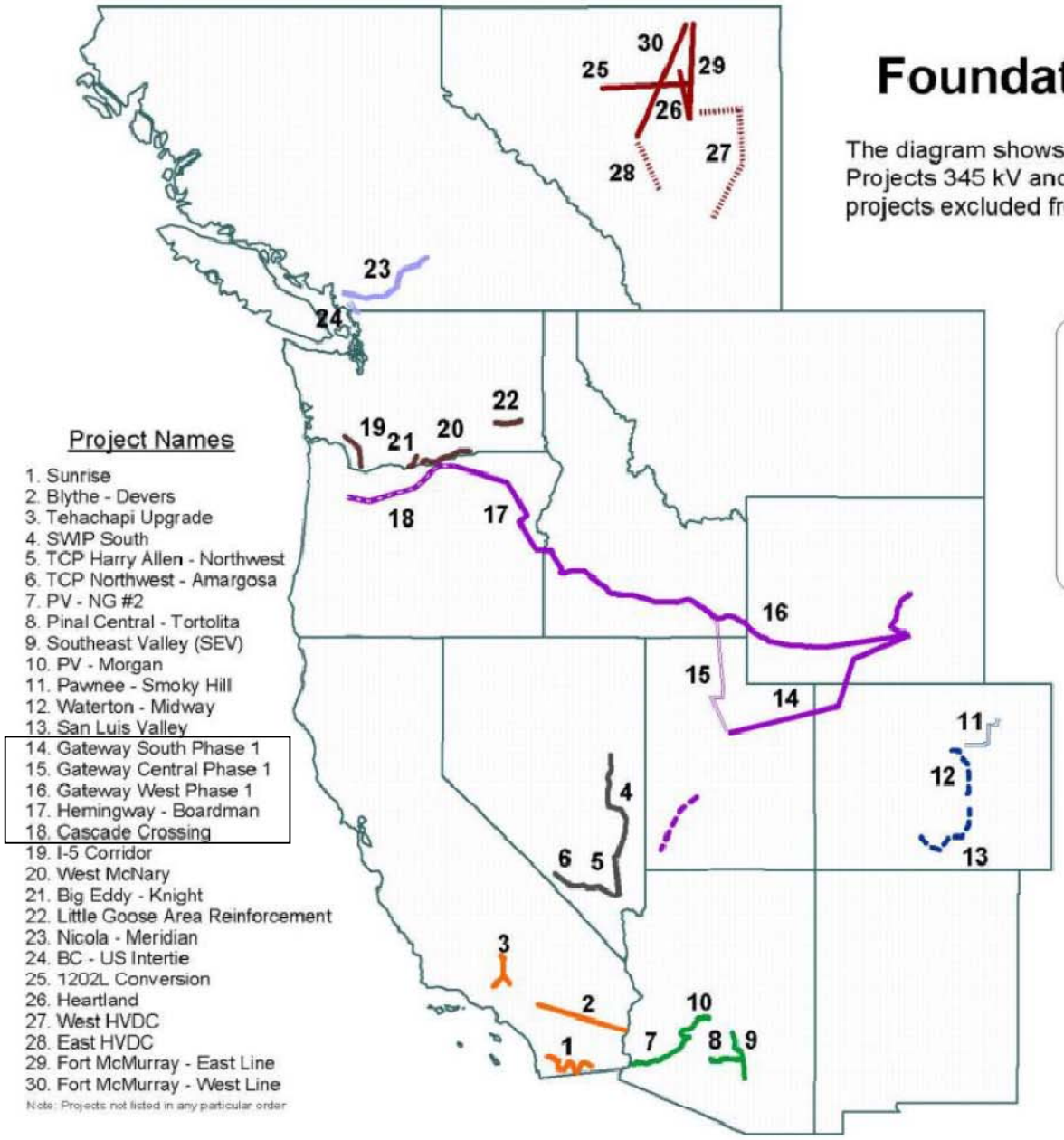






Foundational Projects - 2020

The diagram shows illustrative routings for 30 SCG Foundational Projects 345 kV and higher. There are 10 lower voltage/reinforcement projects excluded from the map for clarity.



Project Names

1. Sunrise
2. Blythe - Devers
3. Tehachapi Upgrade
4. SWIP South
5. TCP Harry Allen - Northwest
6. TCP Northwest - Amargosa
7. PV - NG #2
8. Pinal Central - Tortolita
9. Southeast Valley (SEV)
10. PV - Morgan
11. Pawnee - Smoky Hill
12. Waterton - Midway
13. San Luis Valley
14. Gateway South Phase 1
15. Gateway Central Phase 1
16. Gateway West Phase 1
17. Hemingway - Boardman
18. Cascade Crossing
19. I-5 Corridor
20. West McNary
21. Big Eddy - Knight
22. Little Goose Area Reinforcement
23. Nicola - Meridian
24. BC - US Intertie
25. 1202L Conversion
26. Heartland
27. West HVDC
28. East HVDC
29. Fort McMurray - East Line
30. Fort McMurray - West Line

Note: Projects not listed in any particular order

Transmission Key

- 500 kV Single Circuit Line
- 345 kV Single Circuit Line
- 500 kV Double Circuit Line
- 345 kV Double Circuit Line
- DC Circuit (various voltages)

Sub-Region Key

CAISO	NTTG
SSPG	CG
SWAT	BCH
CCPG	AESO

WECC

Scenario Conclusions

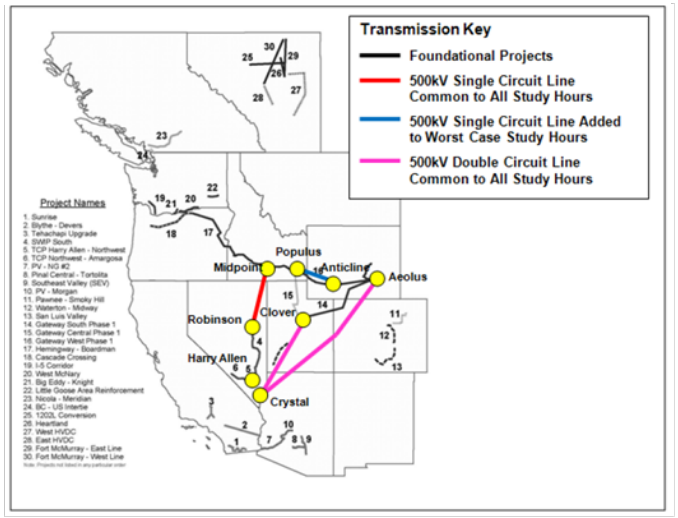
- **Scenario 1: With 6,000 MW in Wyoming**, double-circuit from Aeolus to Crystal plus double-circuit from Clover to Crystal still needs Midpoint-Robinson to get reasonable results. Again DC tie lines should be adequate as well
- **Scenario 2: Adding 3,000 MW in both Montana & Wyoming** works relatively well with double-circuit 500 kV AC from Townsend to Harry Allen via Midpoint & Robinson, a 500 kV line from Aeolus to Crystal & another from Clover to Crystal. DC tie lines of comparable capacity should work as well
- **Scenario 3 & 4: Adding 3,000 MW of generation in either Montana or Wyoming** appears to require 3,000 MW of additional transfer capability through a partial 500 kV double-circuit AC or single-circuit DC solution to deliver via Southern Nevada to Arizona & California
  - **Delivery via Northwest** would require upgrades MT-NW & to COI

Options if Large Wind Expansion

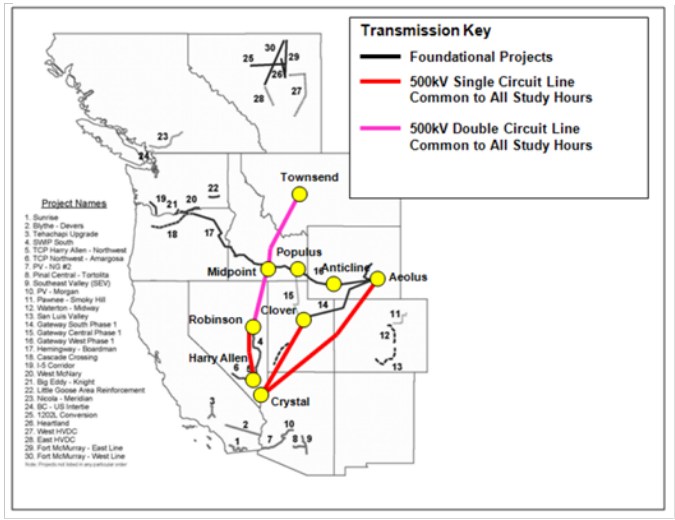
AC Options

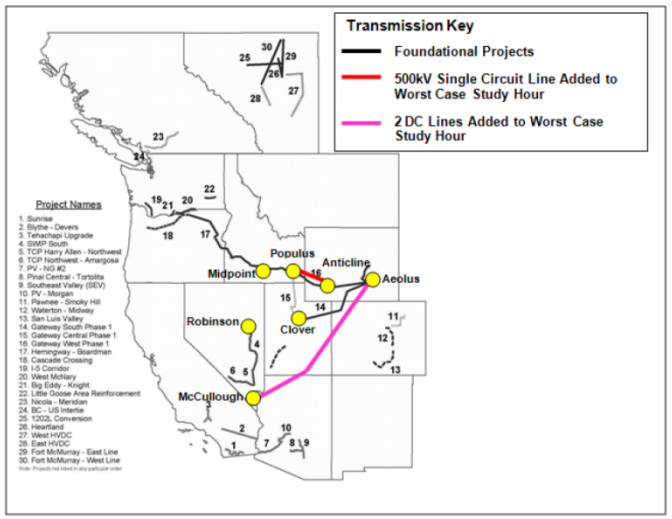
DC Options

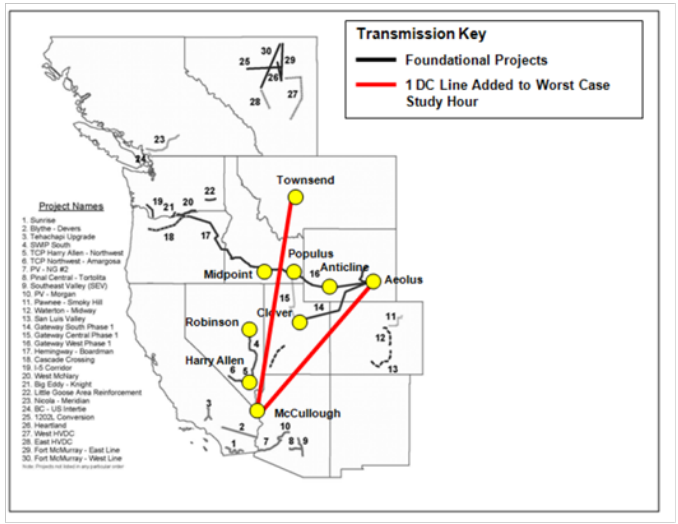
Scenario 1 6,000 MW WY Generic Transmission Improvements



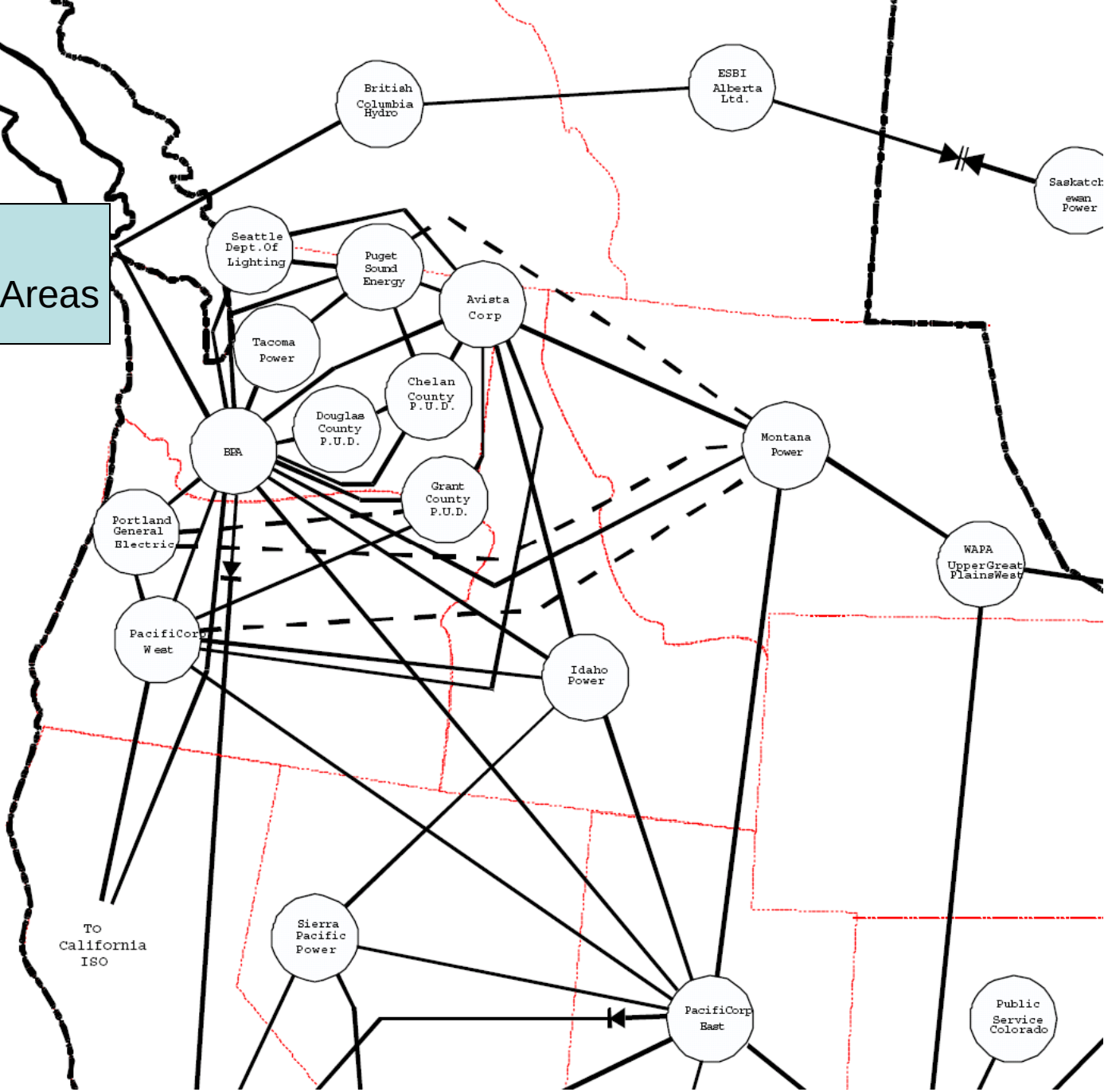
Scenario 2 3,000 MW WY & MT Generic Transmission Improvements

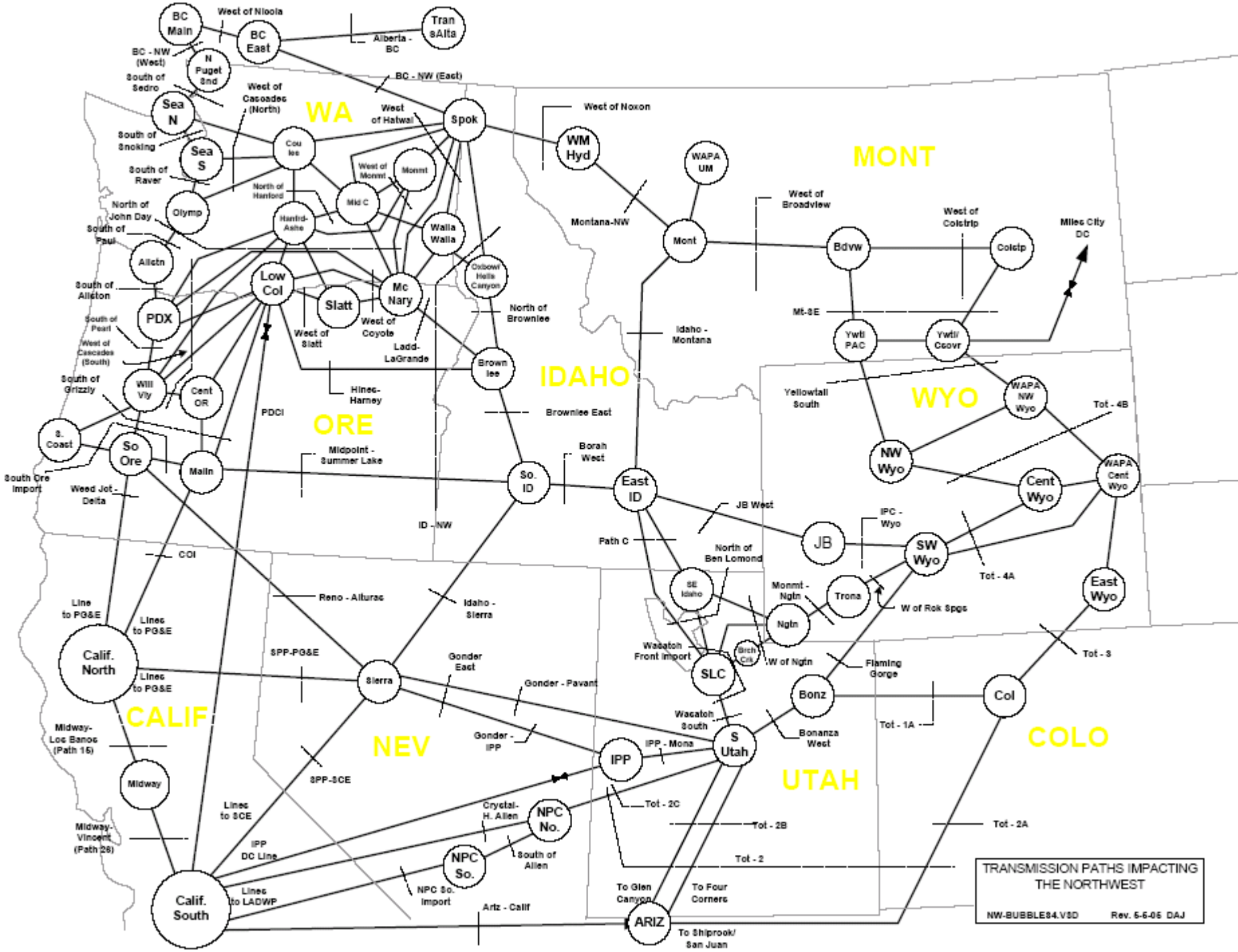






NERC
NW Control Areas




BC Main
West of Nicola
BC East
Tran sAlta
Alberta - BC
BC - NW (West)
N Puget Snd
South of Sedro
BC - NW (East)
West of Cascades (North)
Sea N
WA
West of Hatwai
Spok
West of Noxon
WM Hyd
South of Snoking
Sea S
Cou lee
West of Monmt
Monmt
WAPA UM
MONT
South of Raver
North of Hanford
Mid C
Olymp
North of John Day
Hanfrd-Ashe
Walla Walla
West of Broadview
South of Paul
Montana-NW
Mont
Bdvw
Colstp
Miles City DC
Alistn
Oxbow/ Hells Canyon
South of Alliston
Low Col
Slatt
Mc Nary
West of Coyote
North of Brownlee
Mt-SE
PDX
South of Pearl
West of Cascades (South)
West of Slatt
Ladd-LaGrande
Idaho - Montana
Ywtl PAC
Ywtl/ Ccovr
Brown lee
IDAHO
South of Grizzly
Willi Vly
Cent OR
Hines-Harney
Yellowtail South
WAPA NW Wyo
WYO
Tot - 4B
PDCI
ORE
Brownlee East
S. Coast
So Ore
Midpoint - Summer Lake
Borah West
NW Wyo
WAPA Cent Wyo
South Ore Import
Weed Jct - Delta
Malin
So. ID
East ID
Cent Wyo
JB West
ID - NW
IPC - Wyo
Path C
JB
SW Wyo
North of Ben Lomond
Tot - 4A
COI
SE Idaho
Monmt - Ngtn
Trona
East Wyo
Line to PG&E
Lines to PG&E
Reno - Alturas
Idaho - Sierra
W of Rok Spgs
Ngtn
Wasatch Front import
Calif. North
Lines to PG&E
SPP-PG&E
Gonder East
Sierra
SLC
Birch Crk
W of Ngtn
Flaming Gorge
Tot - 3
Gonder - Pavant
Bonz
Col
CALIF
NEV
Wasatch South
Tot - 1A
Midway- Los Banos (Path 15)
Gonder - IPP
IPP - Mona
S Utah
Bonanza West
COLO
IPP
Midway
SPP-SCE
Lines to SCE
Crystal-H. Allen
NPC No.
Tot - 2C
Tot - 2B
Tot - 2A
Midway- Vincent (Path 26)
IPP DC Line
South of Allen
NPC So.
Tot - 2
UTAH
Calif. South
Lines to LADWP
NPC So. Import
To Glen Canyon
To Four Corners
Ariz - Calif
ARIZ
To Shiprock/ San Juan
TRANSMISSION PATHS IMPACTING THE NORTHWEST
NW-BUBBLE84.VSD
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