Western Hydro - Thermal System Coordination and SMD

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Western system

NERC Map was here in presentation. Removed - too big to insert and keep copy under 1 floppy size.

- To minimize costs to customers, System has evolved with certain features fitting “old” market rules - now transitioning to “new”
- West is LARGE - it’s largeness amplifies the differences between features of a system evolved from the old markets compared with what is desirable in new markets
- Transition to new market design should allow for evolution and fit with features of the Western System

Regional Characteristics

- **Diversity**
  - Geographic Area & Weather Patterns
    - Population Densities
    - Load characteristics
    - Fuel types
  - Generation Types
    - Hydro, Thermal
    - Capacity, Energy
    - Fuel Characteristics
  - Transmission
    - Long & Expensive
    - Tailored to varied requirements
    - Rating Characteristics
  - Ownership & Jurisdictions
    - Gov., Federal, Public, Private
- **Cost Minimization Evolved from Hydro Thermal System Coordination**
  - Forward Bi-Lateral Contracts

WECC Map was here in presentation. Removed - too big to insert and keep copy under 1 floppy size.

Relevant NW History

- **1933 Grand Coulee construction was originally begun for irrigation needs**
- **1937 BPA formed to market Federal hydro power**
- **1948 Vanport flood (washed town of Vanport away) leads to development of multi-use reservoir storage plan for Columbia River Basin**
- **50's Lines built between Columbia and Snake (Walla Walla and Oxbow) for economy sharing**
- **'62 Glen Canyon Dam and Lines, CRSP**
- **1961-64 US and Canada sign Columbia River Treaty, to build storage dams in Canada for flood control, other; allocated benefits**
- **1964 Pacific NW Coordination Agreement (PNCA) signed to meet NW needs by operating the diverse NW hydro-thermal resources to maximize energy and capacity, and operated as if they were owned by a single utility. Allocated benefits to parties**
- **1964 Congress passes NW Regional Preference Act for Federal Hydro as precursor to PAC Intertie construction**
- **Late 60's and 70's as NW becomes increasingly energy short, large base load thermal plant projects completed from coal areas and integrated into PNCA and other agreements**

Relevant NW History

- **1967 Pacific Intertie built to trade surplus NW spring and summer power for California and DSW fall and winter power**
- **1973 Endangered Species Act passed**
- **Mid 70's Eastern ties to the DSW built to broker surplus NW Hydro & Thermal power**
- **Late 70's & 80's Oil Crisis, Congress moves to reduce dependency on foreign oil**
- **1980 Pacific NW Electric Power Planning and Conservation Act passed by Congress**
- **80's and 90's Fish, other Environmental, licensing legislation enacted and further reduce river system electric power flexibility**
- **Late 80's UPL & PPL Merger to capture diversity and expand Hydro Thermal Coordination**
- **90's New market structures and industry change**

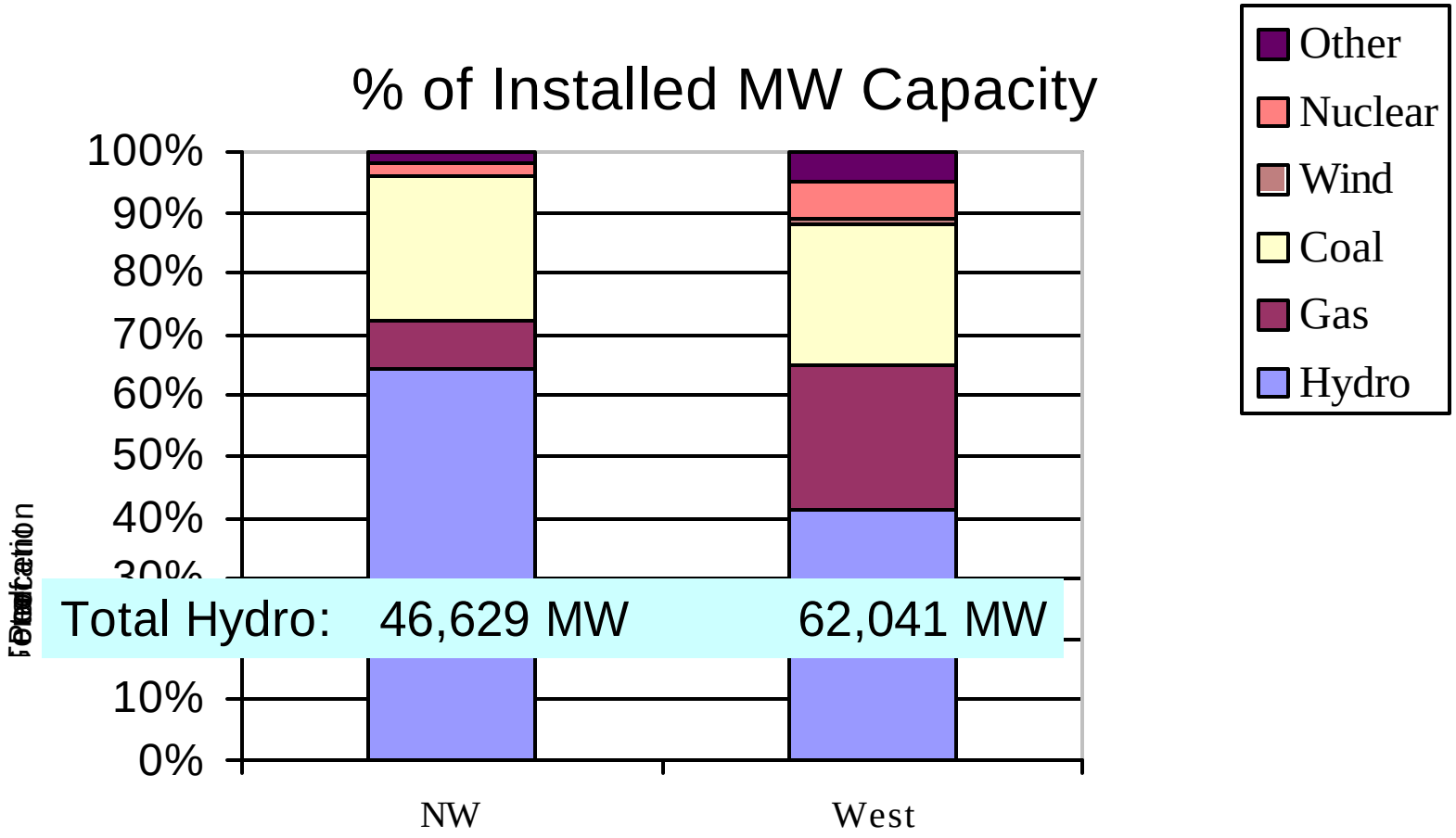
NW Features

- **NW System predominately hydro generation with water supplied by internationally linked river, weather, and snow pack system plus significant and increasing amount of base load thermal generation. Hydro system provides regulation, peaking, and load following to both west and east. Historically, few additional peakers or intermediate type generation needed or built close to loads.**

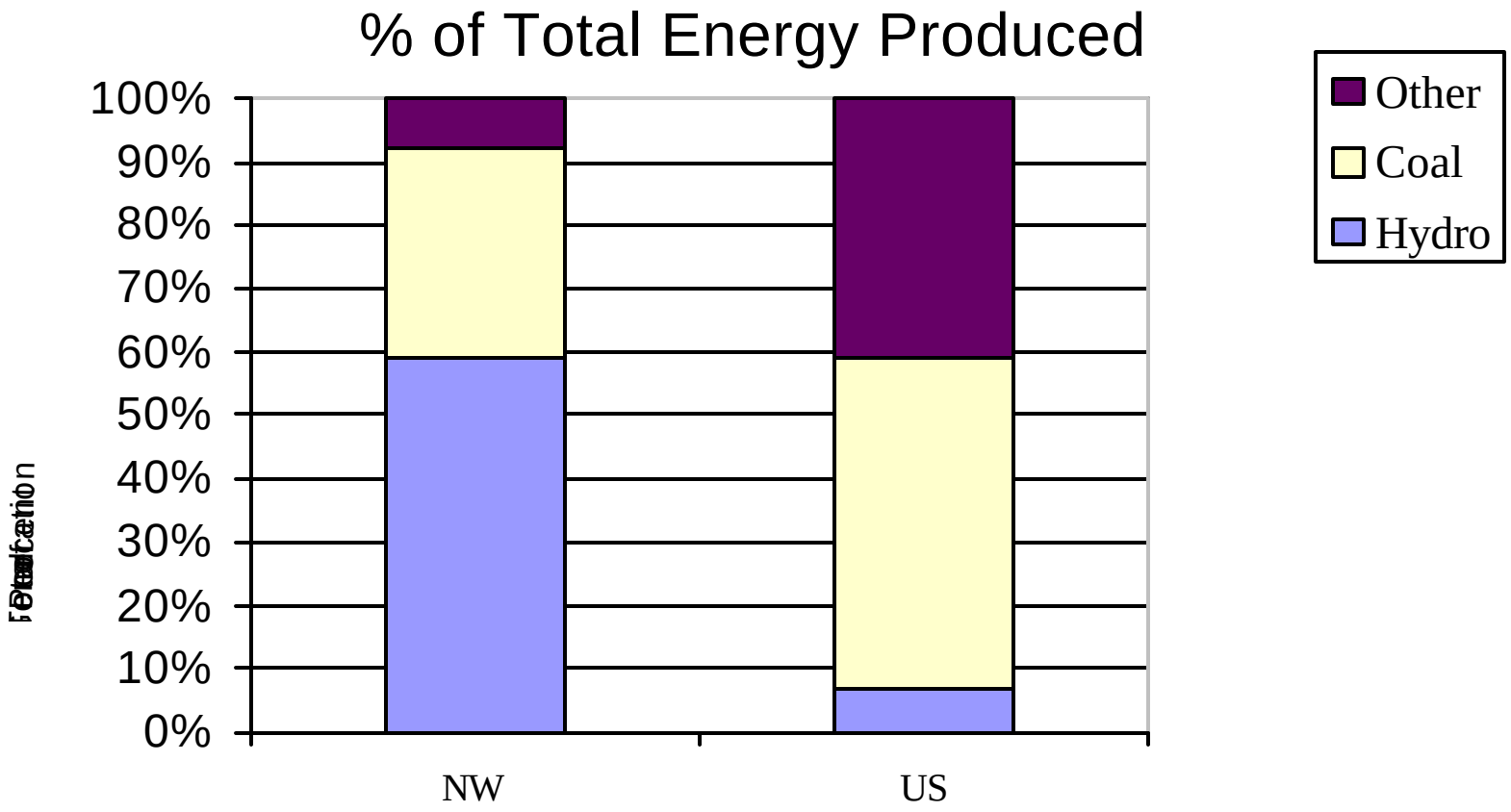
- **Integrated base loaded thermal plants located mostly near coal fields to the east connected via thin transmission system to provide energy to loads in both west and east and recharge river system. Thermal units without fast controls or fuel handling**

- **Hydro-Thermal Coordination and related agreements are used to maximize firm energy and peaking capacity from coordinated system. Objective function of agreements covering multi owned system: to provide minimum long term average annual costs to customers as if system was operated by one utility**

Generation Capacity Comparison as of 1/1/2000



Energy Produced Comparison



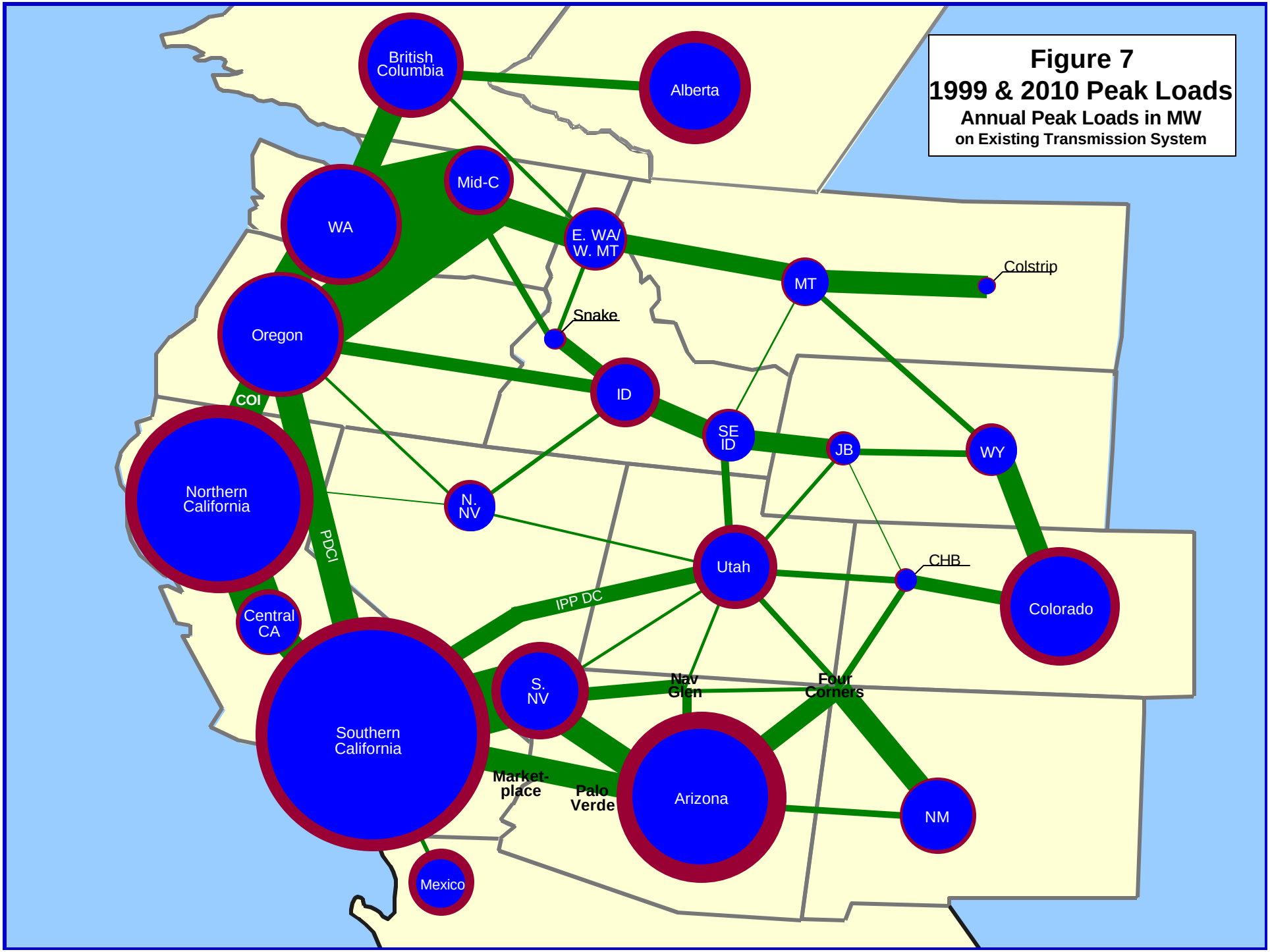
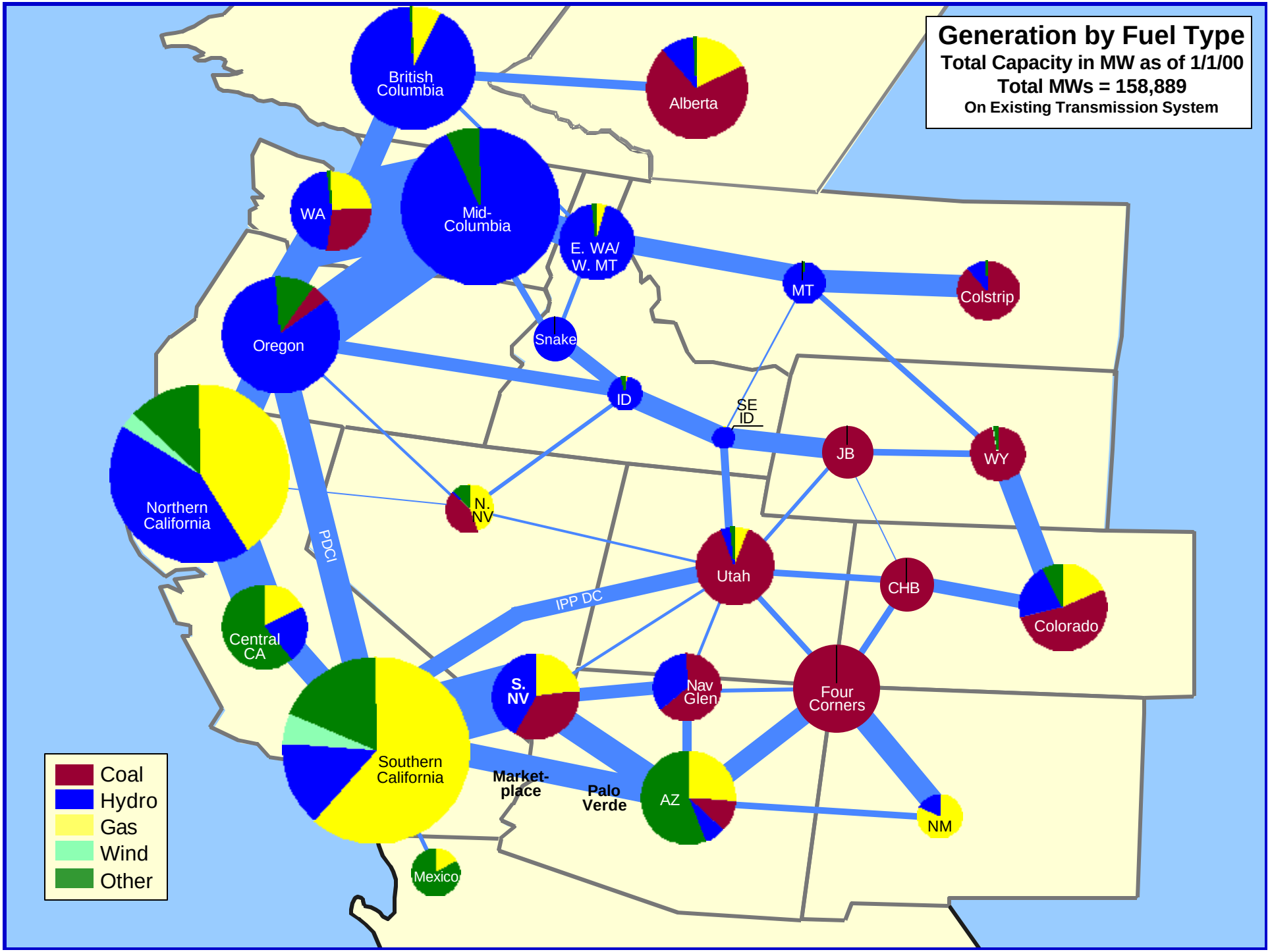
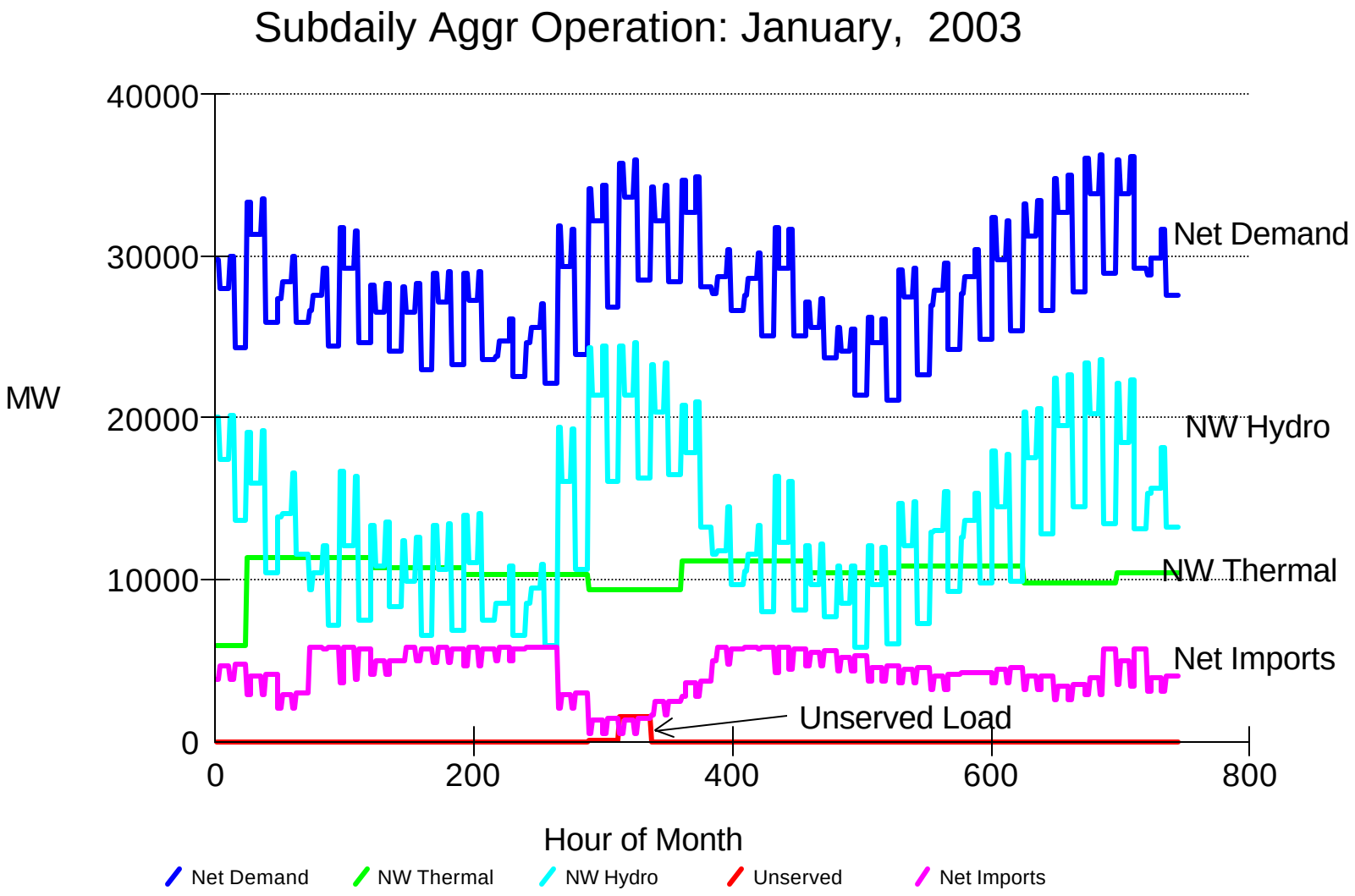


Figure 7
1999 & 2010 Peak Loads
Annual Peak Loads in MW
on Existing Transmission System
British Columbia
Alberta
Mid-C
WA
E. WA/ W. MT
MT
Colstrip
Snake
Oregon
ID
COI
SE ID
JB
WY
Northern California
N. NV
PDCI
Utah
CHB
IPP DC
Colorado
Central CA
S. NV
Nav Glen
Four Corners
Southern California
Market-place
Palo Verde
Arizona
NM
Mexico


Generation by Fuel Type
Total Capacity in MW as of 1/1/00
Total MWs = 158,889
On Existing Transmission System
British Columbia
Alberta
WA
Mid-Columbia
E. WA/ W. MT
MT
Colstrip
Oregon
Snake
ID
SE ID
JB
WY
Northern California
N. NV
PDCI
Utah
CHB
Colorado
IPP DC
Central CA
S. NV
Nav Glen
Four Corners
Southern California
Market-place
Palo Verde
AZ
NM
Mexico
Coal
Hydro
Gas
Wind
Other

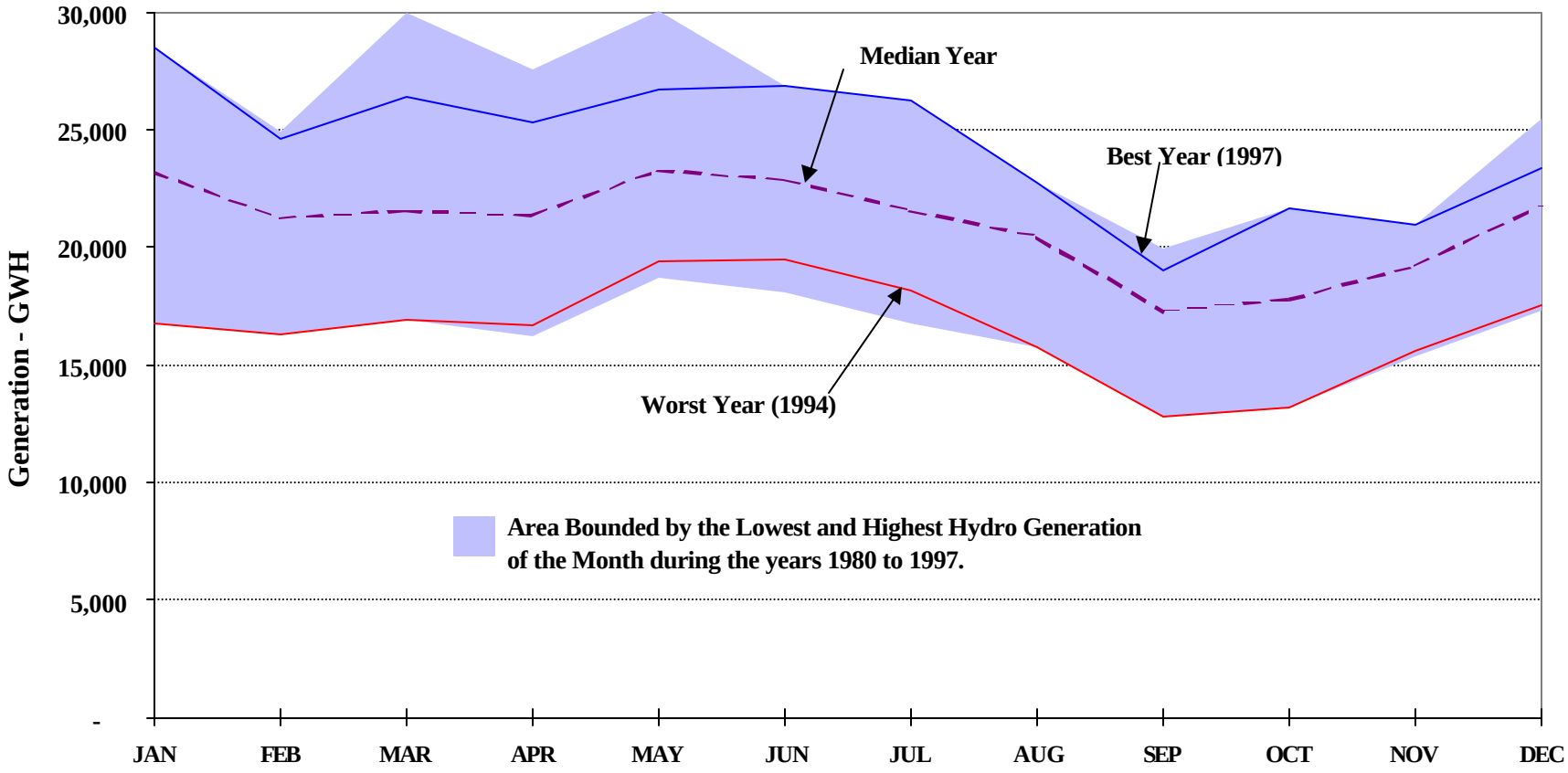
NW Coordinated Hydro-Thermal Generation

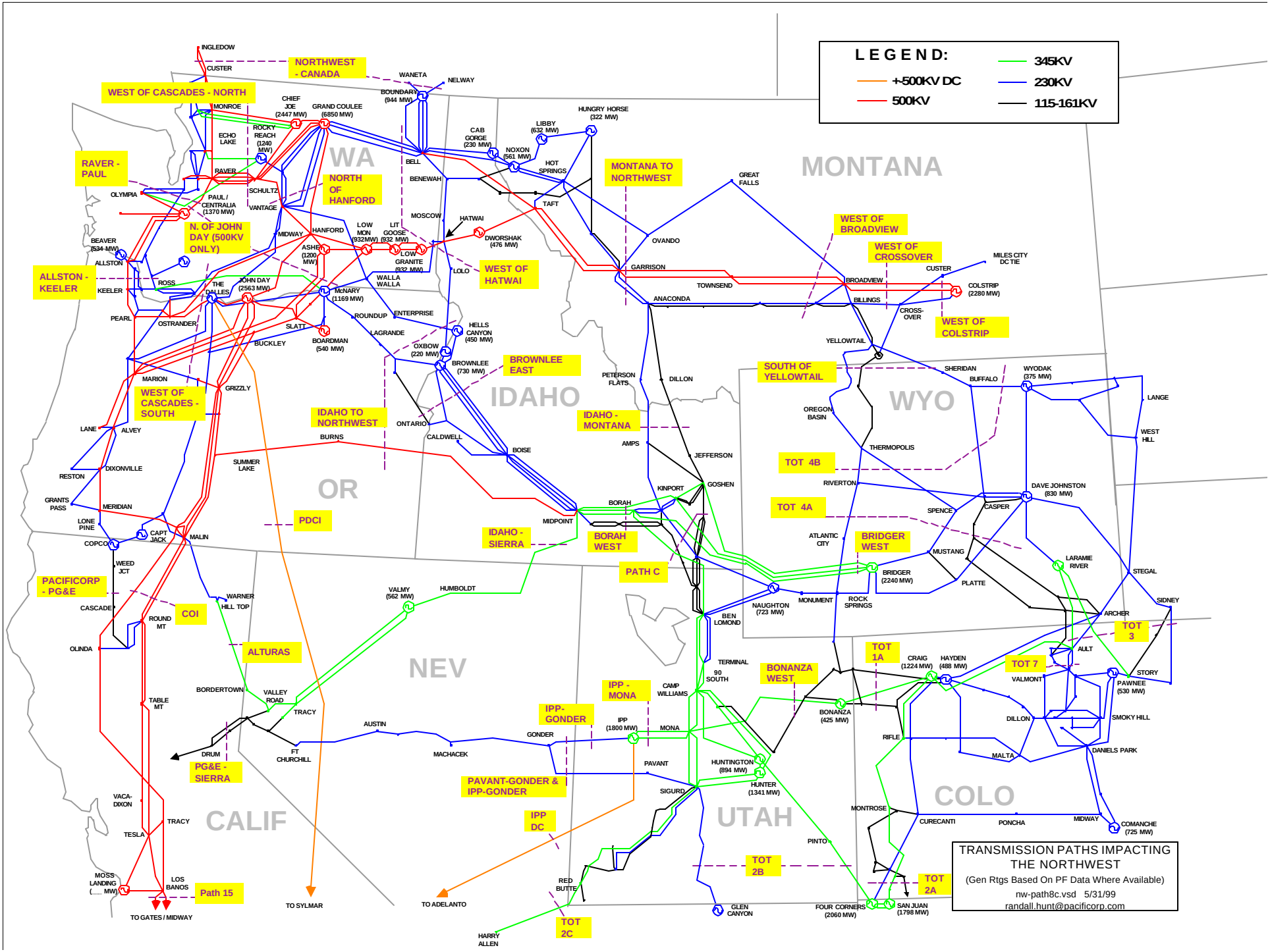


NW Features (cont.)

- **West transmission connecting hydro projects together sized for hydro capacity variations**
- **Transmission linking east thermals to west hydro system sized to transmit energy**
  - Thin, long and expensive
  - Utilizes RAS
  - Nomogram relationships to other paths
  - Diurnal flows
  - Historic flow pattern diversity exploited
  - **Long distance transmission in rural parts of West are also used for distribution. Wholesale customers are served from both T&D.**
- **Many interconnections with other owners and joint ownership of lines/projects requires reciprocity on market design with "Islands" of non-participants (if any)**

WSCC Seasonal Hydro Generation Patterns





TRANSMISSION PATHS IMPACTING THE NORTHWEST

(Gen Rtgs Based On PF Data Where Available)

nw-path8c.vsd 5/31/99

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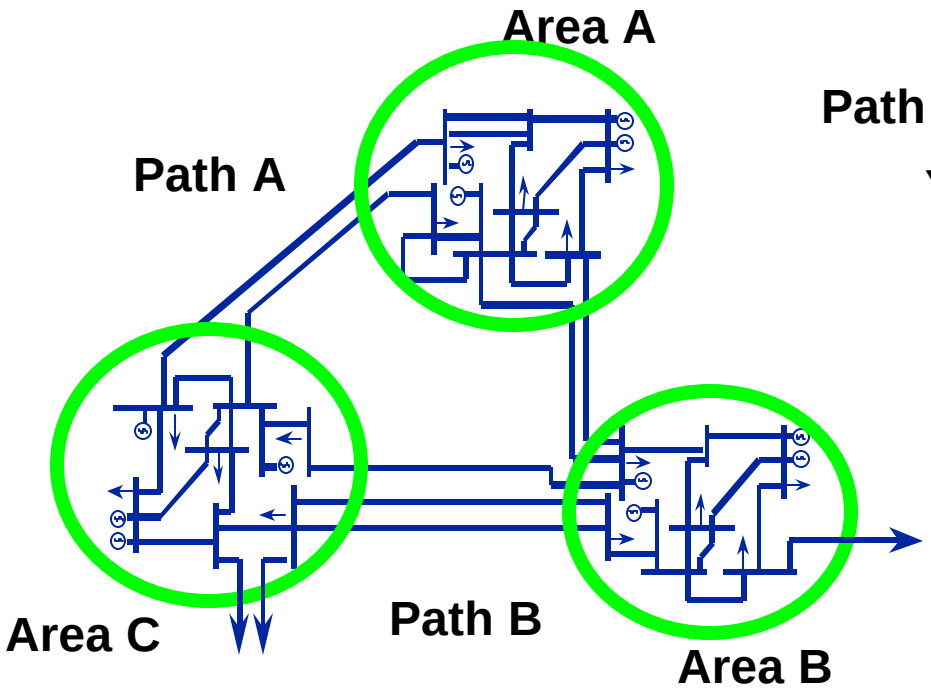
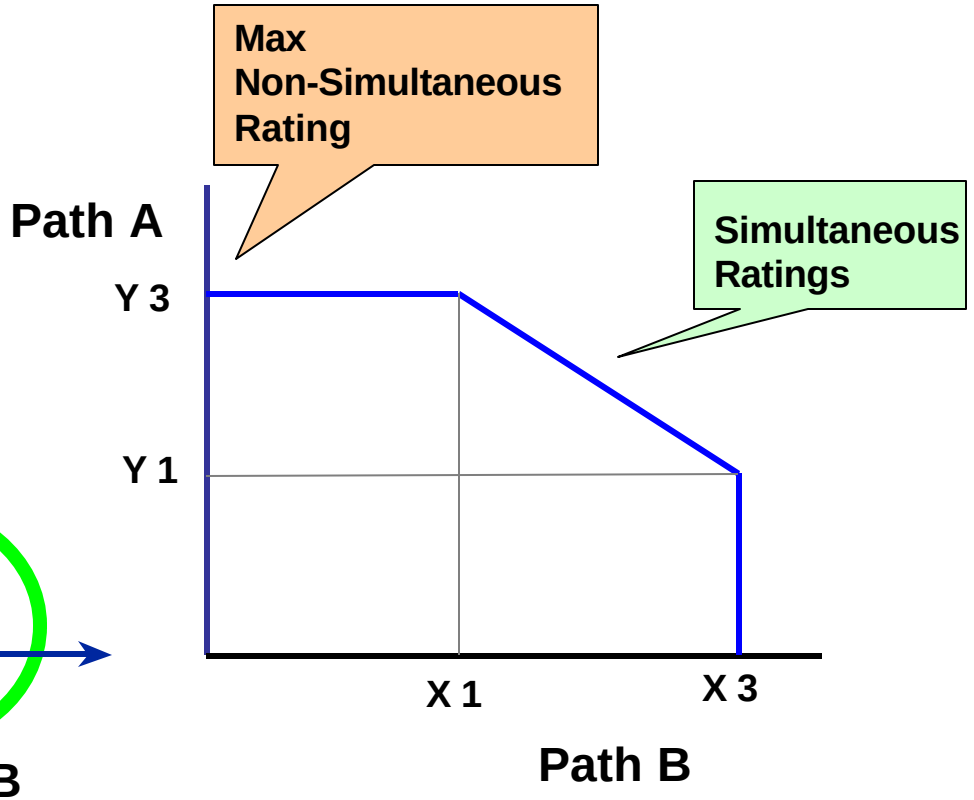
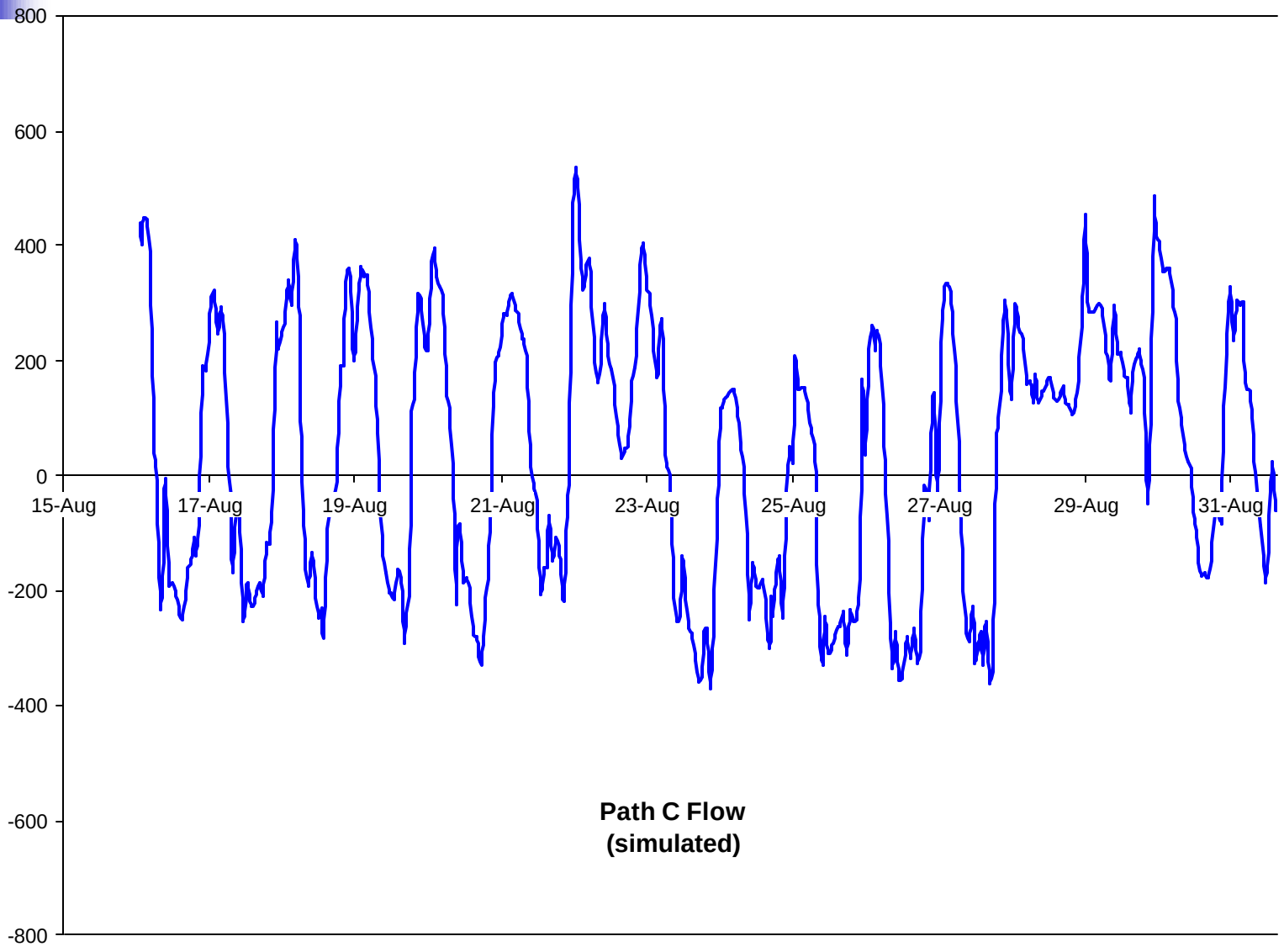
N-1 Ratings, Nomograms, RAS





Path C


800
600
400
200
0
-200
-400
-600
-800
15-Aug
17-Aug
19-Aug
21-Aug
23-Aug
25-Aug
27-Aug
29-Aug
31-Aug
Path C Flow
(simulated)

Coordination Agreements

- Hydro-Thermal coordination Agreements
  - PNCA
    - Optimizes annual Firm Energy Load Carrying (FELCC) and Firm Peak Load Carrying Capability (FPLCC) of participating parties hydro and thermal resources, allocates benefits, specifies operating limits
  - Mid Columbia Hourly Coordination Agreement (MCHC)
- Peaking Contracts
  - BPA Peaking
    - Allows for delivery of peaking capacity (limited on peak hours) with limited energy to flexible delivery points between BPA and PAC System. Energy to be returned over week to specified PODs during off peak periods.
- Jointly Owned Projects
  - Colstrip, Bridger, Centralia
- Diversity Exchanges
- Economic Displacement Arrangements

Coordination Agreements (cont.)

- General Transfer Agreements
- Reliability and Backup
- Reserve Sharing
  - NWPP Reserve Sharing Pool
- Combined Transmission Generation Projects
  - Bridger RTSA
    - Geographic Diversity of Loads
    - Joint Thermal Plant Project
    - Hydro thermal Coordination
    - Transmission Displacement
    - Losses Reduction
- Wheeling Agreements

Connecting the dots to SMD

- **Centralized optimization and dispatch is problematic**
  - Multiple Owners, Bilateral Contracts and Non-Power Use restrictions will make application of standard LMP very challenging
  - Unit commitment driven by non-power factors, based on self commitment, and must be voluntary.
- **Depth and Liquidity of Day Ahead Market**
  - Constrained by requirements for annual optimization of and coordinated operation of hydro and thermal resources
  - Balanced Schedules reflect the bilateral contracts needed to support hydro-thermal coordination
- **Nodal Prices**
  - Based on bids for re-dispatch and energy balancing market
  - Bid Caps may be needed in market power pockets
  - Transmission in many parts of the system is designed to be lean, causing nodal price spreads that will change the historic value of generation
  - Nodes will need to be aggregated into hubs for convenience

Implications to SMD, Cont.

- **Firm Transmission Rights**
  - Options, not Obligations, because of diurnal patterns of use and flow
  - Voluntary conversion from pooled rights (CTRs) to allow for coordinated hydro-thermal operation, the historic evolution and siting of generation on the system, and to avoid cost shifts
- **Scheduling**
  - Scheduling flexibility required to allow optimization of the hydro thermal system
  - Flexibility must be applied equally so as not to adversely impact those segments of the market that are constrained in their operation by hydro-thermal coordination agreements and other bilaterals
  - Balanced Schedules reflect the power deliveries under the bilateral contracts and other agreements
- **Specific Features of WECC system**
  - Nomograms and Phase Shifters extensively used to regulate flows in the western interconnected network
  - A market mechanism will be needed to reflect their operation and use

Implications to SMD

- Hydro-Thermal Coordination has the effect of making generation interdependent across time and across the system.
  - Opportunity cost bids from hydro resources should reflect their expectation of long-term average lost opportunity costs, not spot values
    - Opportunity costs of hydro must reflect the temporal/geographical distribution of resources on the river, and the hydrological conditions
    - Must ensure this does not create market problems under certain river conditions.
  - Allocation of market benefits from on-/off-peak prices must reflect coordination agreements
    - Hydro units have flexibility to meet load peaks, reserve and AS: set on-peak prices
    - Thermal units supply system base load: set off-peak prices
    - In effect thermal units ‘re-charge’ hydro reservoirs
  - Must not confuse hydro-thermal coordination designed to optimize hydro energy extraction with improper market behavior