2010-2011

# *Biennial Transmission Plan*

## SUMMARY

NORTHERN TIER
TRANSMISSION GROUP

# NTTG Mission

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

The Hemmingway 500 kV substation bus in Idaho.

On the cover: The 500 kV Colstrip transmission system looking east from Townsend, Mont.

NORTHERN TIER TRANSMISSION GROUP
www.nttg.biz
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## NTTG Members' Transmission Facilities


The extensive high-voltage transmission network of the Northern Tier Transmission Group's transmission providers reaches to all states of the U.S. Western Interconnection.

# 1. Introduction

This document summarizes the Northern Tier Transmission Group 2010-2011 Biennial Transmission Plan. It highlights the key conclusions of the plan and provides limited background on the plan purpose and process. The complete plan offers greater detail, background and graphics. If you want more information after you review this document, visit the NTTG web site (www.nttg.biz) and download the plan.

The NTTG 2010-2011 Biennial Transmission Plan sought to determine transmission system improvements needed for reliable operation in the year 2020 within the NTTG footprint of the western United States. The plan included economic studies and a transmission study. The heart of the plan was the transmission study, comprising three components.

First, the transmission study established the inadequacy of the existing transmission system to reliably handle forecasted 2020 NTTG system electrical load.

Second, Core Cases examined five hours representing times of heavy NTTG footprint electrical load, transmission import and transmission export stress. Power flow reliability analysis on the five Core Cases demonstrated the adequacy of expected transmission upgrades to reliably integrate planned energy resources and serve forecasted NTTG system load.

Third, Scenario Cases applied four different, theoretical wind generation configurations against the five Core Cases. The resource additions in these Scenario Cases exceeded the capability of the NTTG transmission system and its expected transmission upgrades. Therefore, the study plan concluded, the NTTG transmission system will require additional AC and/or DC transmission to reliably provide for these resource expansion scenarios.

This summary will explain the three components of the transmission study, including the study conclusions, as well as the economic studies performed. But first, the overall purpose of the plan, and the process used to create it, will be highlighted.

# 2. Plan Purpose

The study plan established – given a limited number of load and resource scenarios developed through production cost simulation – the general transmission improvements needed for feasible system operation at times of transmission stress 10 years in the future. The transmission planning process advanced three goals:

1. identify transmission needs of transmission customers
2. identify and evaluate transmission congestion that impedes efficient operation of electricity markets
3. consider the impacts on congestion of potential new generation facilities or new transmission projects

# 3. Planning Process

The NTTG biennial transmission planning process proceeded in steps during eight quarters and along two tracks. The table below diagrams this process for the 2010-2011 cycle.

## NTTG Eight-Quarter Biennial Process

The cycle began in January 2010 with a three-month window of opportunity for stakeholders to submit data for loads, resources and transmission projects to be studied, and to submit requests for economic congestion studies.

The second quarter was dedicated to developing a study plan and the appropriate study assumptions. Additionally, development of economic studies ensued during this quarter.

The Economic Studies Team presented its economic congestion study results for the biennium in the third quarter of 2010.

The Northern Tier Technical Working Group (TWG) devoted the third and fourth quarters of 2010 and the first quarter of 2011 to the creation of the production cost cases to be exported to the power flow simulation program. There were significant modeling differences to overcome in order to generate acceptable power flow cases.

Work in 2011 began with the conduct of the second economic study request. During the second quarter of 2011, the power flow cases were subjected to N-1 contingency analyses. Any lack of compliance with NERC Reliability Standard and WECC Standard requirements were examined. All thermal overloads and voltage excursions were verified. The Planning Committee deemed the resulting power flow studies acceptable.

The biennial planning process concluded with the preparation, review and acceptance of this report.

### NTTG EIGHT-QUARTER BIENNIAL PROCESS

| NTTG Biennial Planning Cycle | | Year | | NTTG Economic Study Cycle |
|---|---|---|---|---|
| Gather Information | 01 | 2010 | 01 | Economic Study Requests |
| Develop Study Plan, Assumptions | 02 | 2010 | 02 | Perform Economic Studies |
| Perform Draft Plan Analysis | 03 | 2010 | 03 | Report and Review |
| Perform Draft Plan Analysis | 04 | 2010 | 04 | |
| Prepare & Review Draft Report | 05 | 2011 | 01 | Economic Study Requests |
| Process Econ. Studies, Cost Alloc. | 06 | 2011 | 02 | Perform Economic Studies |
| Prepare & Review Final Report | 07 | 2011 | 03 | Report and Review |
| Obtain Final Plan Approval | 08 | 2011 | 04 | |

# 4. Economic Studies

## Objectives

NTTG transmission providers are obligated through their transmission tariffs, in compliance with Federal Energy Regulatory Commission (FERC) Order 890, to perform economic planning studies. This requirement is based on FERC's finding that transmission planning involves both reliability and economic considerations.

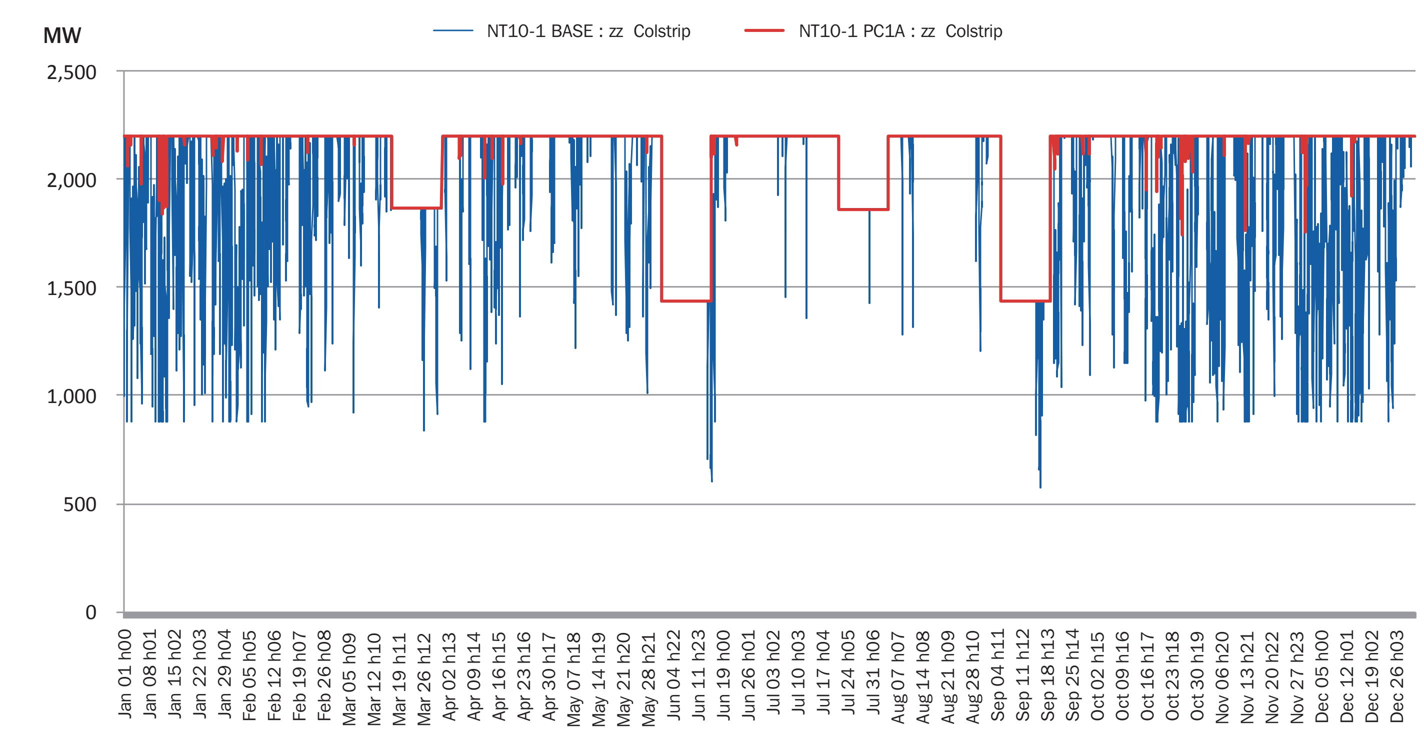
In the transmission planning process, each transmission provider offers stakeholders with the right to request economic planning studies. These studies evaluate transmission upgrades to reduce congestion or integrate new resources and loads.

NTTG performs up to two high-priority subregional studies during its two-year transmission planning process. Additional economic planning studies may be requested and funded by a stakeholder. Also, economic study requests may be merged if the requests are similar in scope.

## Economic Study Requests

Over the biennium, NTTG received 45 economic study requests. Most of these were regional in scope and were forwarded to the appropriate regional body for consideration. Three requests were deemed relevant for study due to their subregional nature. The three subregional requests were clustered into one study to assess the impact of

**FIGURE 1**
Colstrip Production Impacts from 1,500 MW of Wind Generation



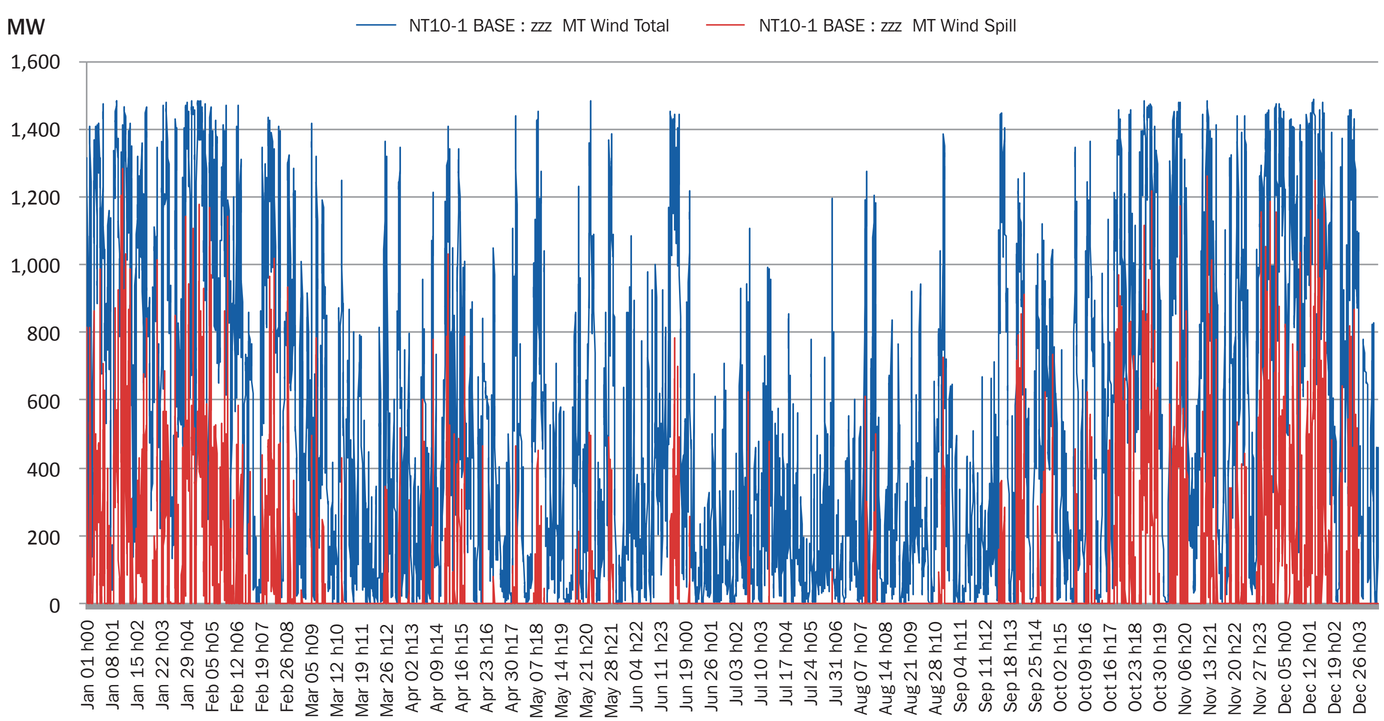
the transmission expansion on resource additions in Montana. In general, the economic analysis found that additional transmission is needed to accommodate increases in wind energy resources beyond those presently planned.

## Results and Observations

The 1,000 MW of new Montana wind resources already modeled in the TEPPC 2019 base case are accommodated with modest coal plant cycling and little wind curtailment. The addition of 1,500 MW of wind generation in Montana causes severe cycling of base load coal generation as shown in Figure 1 below. Without additional transmission, much of the additional wind energy cannot be accommodated by existing transmission and is curtailed as shown in Figure 2.

Upgrading the capacity of Paths 8 and 18 provides some benefit, but a large fraction of the additional wind energy remains unusable. However, the addition of the Mountain States Transmission Intertie (MSTI) project provides the ability to transmit most of the added wind out of Montana to locations that are able to absorb the increased generation with modest re-dispatch of existing resource. The Path 8 upgrade and MSTI projects significantly decrease the hours of congestion for the south and west Montana transmission paths.

**FIGURE 2**
Wind Generation Curtailments Due to Transmission Constraints



# 5. Transmission Study

## Objectives

The overall objective of the 2010-2011 Northern Tier Transmission Plan was to determine the configuration of a reliable transmission system in 2020. The plan used a conceptual study to examine, given a limited number of forecasted and assumed load and resource portfolios, the generic transmission additions required to provide feasible system operation at forecasted stress times, 10 years in the future.

In 2011, analyses were performed to determine the capability of the existing system with a set of upgrades defined as the WECC Foundational Transmission Project additions and to identify generic transmission improvements to resolve any reliability standard violations. These analyses, or Scenario Cases, formed the basis for the NTTG Transmission Plan.

Specifically, the transmission plan objectives were designed to:

1. Identify transmission needs of transmission customers (e.g., retail native load, network and point-to-point), as identified by and provided to the transmission provider. Transmission providers were required to consolidate this information for their particular system to include in the subregional planning process.
   a. Native load needs were incorporated by input from the various states' integrated resource planning (IRP) processes, where they existed.
   b. Network transmission customers were asked to submit information on their projected loads and resources on a comparable basis (e.g., planning horizon and format). The intent was to plan for all end-use loads on a comparable basis.
   c. Each transmission provider's existing point-to-point customers were asked to submit their projected service needs, along with receipt and delivery points, over the planning horizon.
2. Identify transmission congestion that impedes the efficient operation of electricity markets. Congestion on the existing and planned system was reviewed and evaluated.
3. Consider the impacts on congestion of potential new generation facilities or new transmission projects. This included production simulation studies on a subregional and regional level, and historical use analysis as provided by the Northern Tier Use Committee and TEPPC subcommittees.

To meet the above objectives, the Planning Committee devised a study plan with three major components. Figure 3 illustrates the framework of the study components comprising a Null Case, Core Case and Scenario Cases.

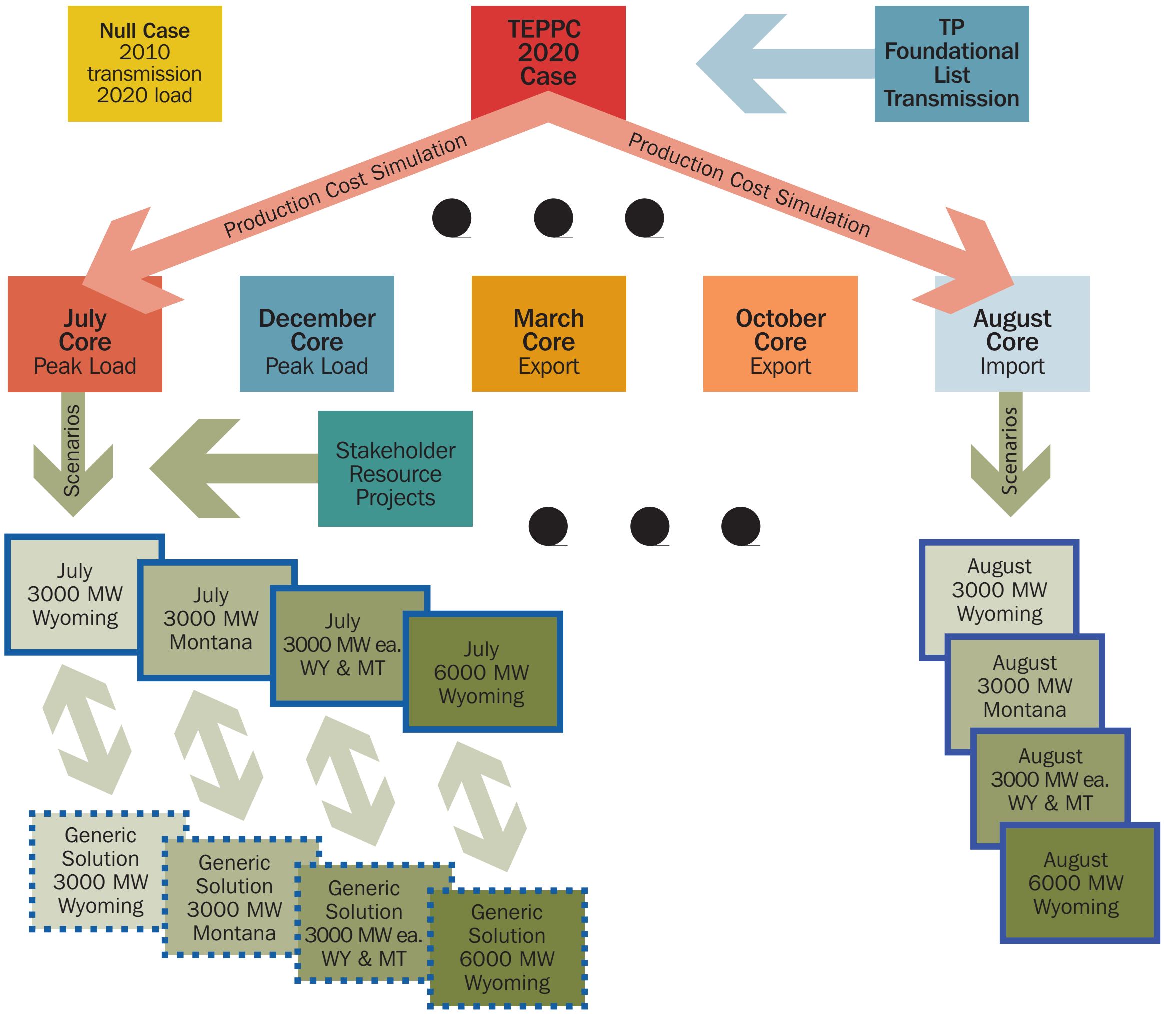



**FIGURE 3**
Transmission Study Framework

# Null Case

## Purpose

The Null Case projected how the existing transmission system would perform against the demands of the forecasted NTTG footprint load level in the year 2020 without the addition of new transmission or energy resources.

For a baseline, the load in the WECC 2010 heavy summer (10hs3bp) base case was modified to reflect the NTTG area 2019 load forecasts. This baseline, or Null Case, projected how the existing transmission system would perform without the addition of new transmission or energy resources.

## Methodology

The Null Case was developed from the WECC 2010 heavy summer (10hs3bp) base case. In the 2010 heavy summer base case, loads present in the NTTG footprint were increased to the 2020 heavy summer (20hs1ap) base case levels. A total of 3,170 MW (approximately 1.4% compounded annually) of load was increased in the NTTG footprint. Loads outside the NTTG footprint were kept at the 2010 levels.

The transmission topology was not changed from the WECC 2010 heavy summer base case. Transmission upgrades present in the WECC 2020 heavy summer base case and new generation resources were not included in the Null Case study. NTTG footprint resources existing in the WECC 2010 heavy summer base case and WECC 2010 heavy summer base case resources in other areas were increased, if possible, to meet the load increase. No generation resource was increased beyond its maximum generating capability.


A line crew receives training at the Broadview, Mont., 500 kV training station.

Power flow analysis was performed on the Null Case to determine if any voltage or thermal overload issues existed with all lines in service (i.e., N-0 condition) and with one transmission element out-of-service (i.e., N-1 condition), including auto transformer outages. All N-1 outages for transmission elements above 200 kV were studied for the NTTG footprint. No N-2 (or higher) outages were taken.

## Conclusions

The Null Case power flow analysis discovered overloads on transmission elements under normal system operating conditions and single-element outage conditions. Voltage issues were also observed on several 500 kV busses and at other voltage levels under certain N-1 outage conditions. The Null Case study found that the overloads on the transmission system increased beyond acceptable levels when compared with the NERC and WECC planning criteria.

The study concluded that the existing transmission infrastructure cannot reliably serve estimated 2020 load. Additional transmission capacity would be necessary to meet both NERC and WECC planning criteria and to reliably meet future loads. These upgrades are defined by the transmission providers as the Foundation List Projects and are used in the development of the Core and Scenario cases.

The Hemmingway 500 kV substation shunt capacitor bank in Idaho.

## Core Cases

### Purpose

Concurrently with development of the Null Case, the Planning Committee created a set of five Core Cases to analyze future system reliability during selected peak load hours and high import and export conditions.

### Methodology

The NTTG Planning Committee used an integrated one-hour loads and resources analysis to determine transmission system stress that could occur 10 years in the future due to increased load and energy resource additions.

The selection of several hours of transmission constraint and peak load formed the basis, or core, of the study. These Core Cases were developed by exporting production cost simulation data to a power flow program for five hours representing: heavy load hours, maximum export hours and maximum import hour. The Core Cases contained the base system and resource and loading conditions for the Scenario Cases that followed.

The plan conceived of a model of the 2020 network based on the existing system, with the addition of a minimal set of committed transmission projects. Only those transmission projects deemed to have a high probability of being in service before 2020 and to be primarily for firm load service and reliable system operation were included in this set (i.e., the Foundational Transmission Projects were included).

This transmission network was then tested. The assessment used a commitment and dispatch program and the TEPPC 2020 PC0 core base case. To determine where system stresses existed, the assessment ran the load and resource scenarios under the hour-by-hour operating conditions across the year 2020 (8,784 hours). To determine times of stress, the TWG used maximum NTTG summer and winter peak loads and times of aggregated maximum imports and exports on eastern NTTG paths. Then, for the most highly stressed hours, the load and resource states were exported to a power flow program for reliability analysis.

## Selecting Hours for Power Flow Analysis

Examining hourly flows on 12 WECC paths, the Northern Tier TWG reached consensus to study transmission congestion that would likely occur during peak loads and high-transfer hours. These hours represented times when local load-serving transmission could be stressed and when transmission used to export out of or import into NTTG footprint could be stressed. High-transfer hours were selected representing hours with maximum flows resulting in paths at or near their limits. Another reason to study high-transfer times was that remote development of renewable resources that could meet renewable portfolio standards in the Southwest may lead to high flows to those loads. The peak load and high transfer hours studied included:

| PEAK LOAD HOURS | REPRESENTING |
|---|---|
| a. July 27, Hour Ending 16:00 | Summer peak |
| b. December 22, Hour Ending 18:00 | Winter peak |
| **HIGH TRANSFER HOURS** | **REPRESENTING** |
| c. March 2, Hour Ending 21:00 | Highest spring exports |
| d. October 4, Hour Ending 21:00 | Highest fall exports |
| e. August 10, Hour Ending 13:00 | Highest annual import |

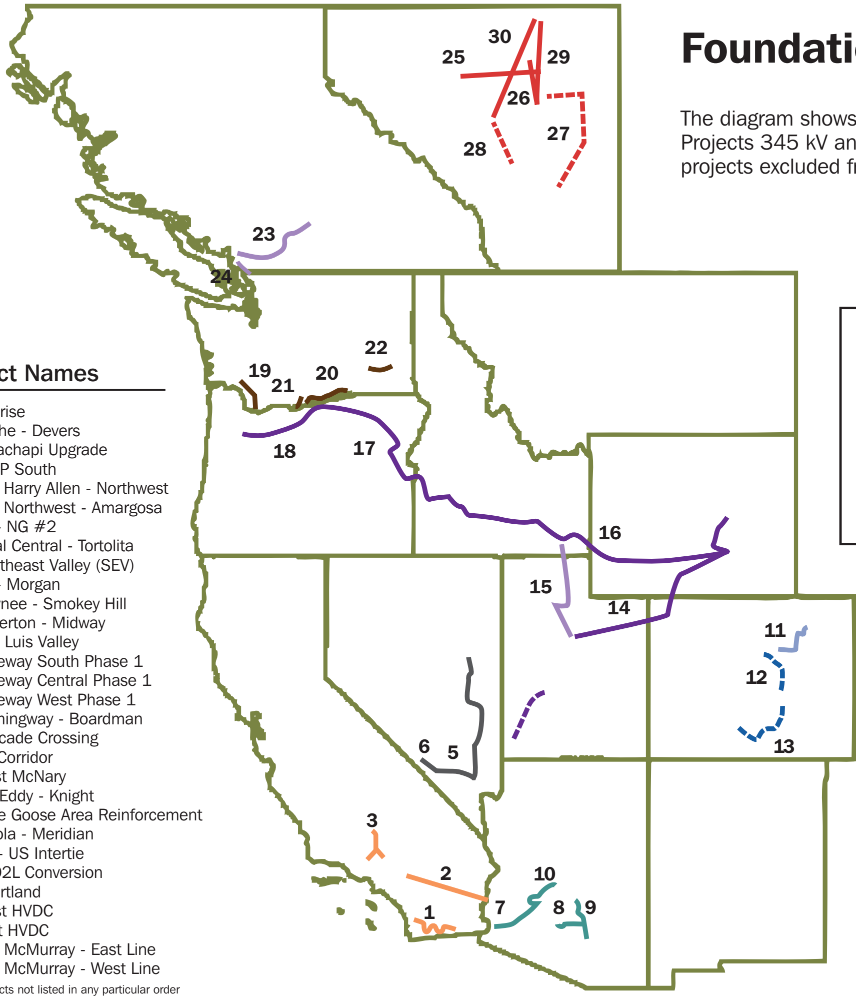
These five selected hours as exported from the economic model were referred to as the "Core Cases." These contained the 2020 loads and generation as modeled in the TEPPC economic data, including the Foundational Transmission Projects (see Fig. 4), before any NTTG generation scenarios were applied to them.

## Conclusions

The power flow reliability analysis of the Core Cases demonstrated that the Foundational Transmission Projects increase the system capability to reliably integrate planned energy resources and serve the forecasted NTTG system load. These Foundational Transmission Projects were developed by the Subregional Planning Group Coordination Group and adopted by the Western Electricity Coordinating Council's Transmission Expansion Planning Policy Committee (TEPPC).

# 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 - Smokey 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

**FIGURE 4**
Foundation
Projects – 2020

# Scenario Cases

## Purpose

Four Scenario Cases were developed from the Core Cases to represent four different resource scenarios. The four Scenario Cases are shown below:

| |
|---|
| 1. 6,000 MW in Wyoming |
| 2. 3,000 MW in Wyoming<br>3,000 MW in Montana |
| 3. 3,000 MW in Montana |
| 4. 3,000 MW in Wyoming |

Within each of the four scenarios, five study hours were selected. The five study hours are shown below:

| | |
|---|---|
| 1. Summer Peak | July 27, Hour 16 |
| 2. Winter Peak | December 22, Hour 18 |
| 3. Heavy Spring Export | March 2, Hour 21 |
| 4. Heavy Autumn Export | October 4, Hour 21 |
| 5. Maximum Import | August 10, Hour 13 |

## Methodology

The Scenario Cases applied the four different wind generation configurations against the five Core Cases – 20 scenarios in all. Each study hour within a Scenario Case was evaluated using load flow analysis to identify the minimum amount of transmission improvements required to reduce transmission path flows to acceptable reliability levels. Single element (N-1) contingency analysis was performed on all five study hours for each scenario to evaluate the performance of the system. Each of these scenarios is examined in detail in the full report.

## Conclusions

The resource additions in the Scenario Cases exceeded the capability of the NTTG transmission system and its Foundational Transmission Projects. Therefore, the NTTG system will require additional AC and/or DC transmission to accommodate these resources.

The maps on pages 14–19 show generic transmission improvements deemed to be adequate solutions for relieving overloads and that were common to the five study hours for each of the four Scenario Cases. Scenarios 1 and 2 show solution options for both AC and DC lines. Other generic transmission lines with different beginning and ending substations may also resolve the reliability problems identified in the studies.

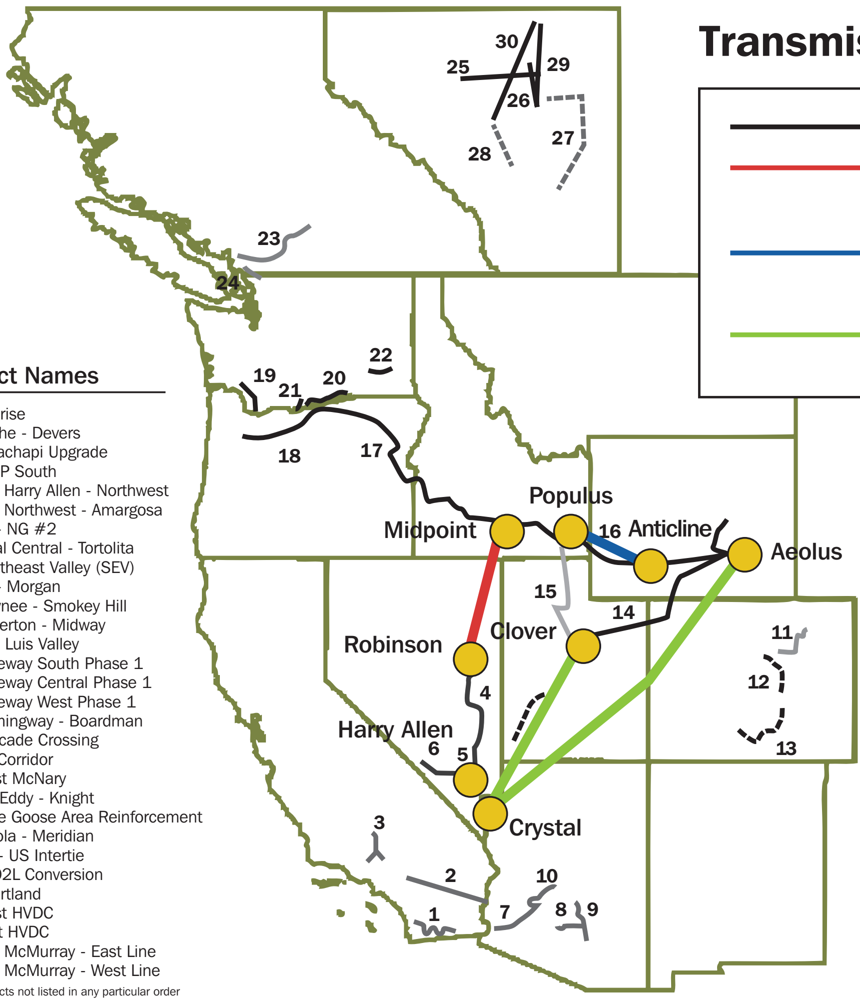
## Transmission Study Summary

The NTTG TWG performed reliability analysis in the traditional method using the Null Case to analyze the performance of the existing NTTG transmission system to serve the increased loads forecasted for the year 2020. The method of exporting production cost simulation to power flow cases was successfully developed and allowed the simulation of five NTTG transmission system loading conditions representing heavy load, maximum export and maximum import conditions. These production cost simulation-generated cases were further analyzed for performance under the addition of 3,000 MW of wind generation in Montana or Wyoming, or both; and 6,000 MW in Wyoming.

In conclusion:

1. The NTTG TWG, through the Null Case analysis, determined that the existing NTTG transmission system is not adequate to serve the projected NTTG system load in the year 2020.
2. The NTTG TWG demonstrated the ability to develop hourly power flow cases from production cost simulation exports. This provides the ability to identify and perform reliability analysis on an appropriate set of transmission system loading conditions for future system dispatch configurations.
3. The Core Cases power flow reliability analysis demonstrated that the WECC TEPPC Foundational Transmission Projects increase the system capability to reliably integrate planned energy resources and serve the forecasted NTTG system load.
4. The Scenario Cases showed that the development of large amounts of Montana or Wyoming wind generation will exceed the capability of the NTTG transmission system and its Foundation List Projects. Therefore, additional AC, DC, or a combination of AC and DC transmission from the NTTG system to forecasted Renewable Portfolio Standard (RPS) driven load will be required under these resource expansion scenarios.

A NWE crew changes bell string during live maintenance on 500 kV Colstrip transmission system.




## Transmission Key

- Foundational Projects
- 500 kV Single Circuit Line Common to All Study Hours
- 500 kV Single Circuit Line Added to Worst Case Study Hours
- 500 kV Double Circuit Line Common to All Study Hours

### 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 - Smokey Hill
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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

**FIGURE 5**
Scenario 1: 6,000 MW Wyoming Generic Transmission Improvements (AC Solution Option)

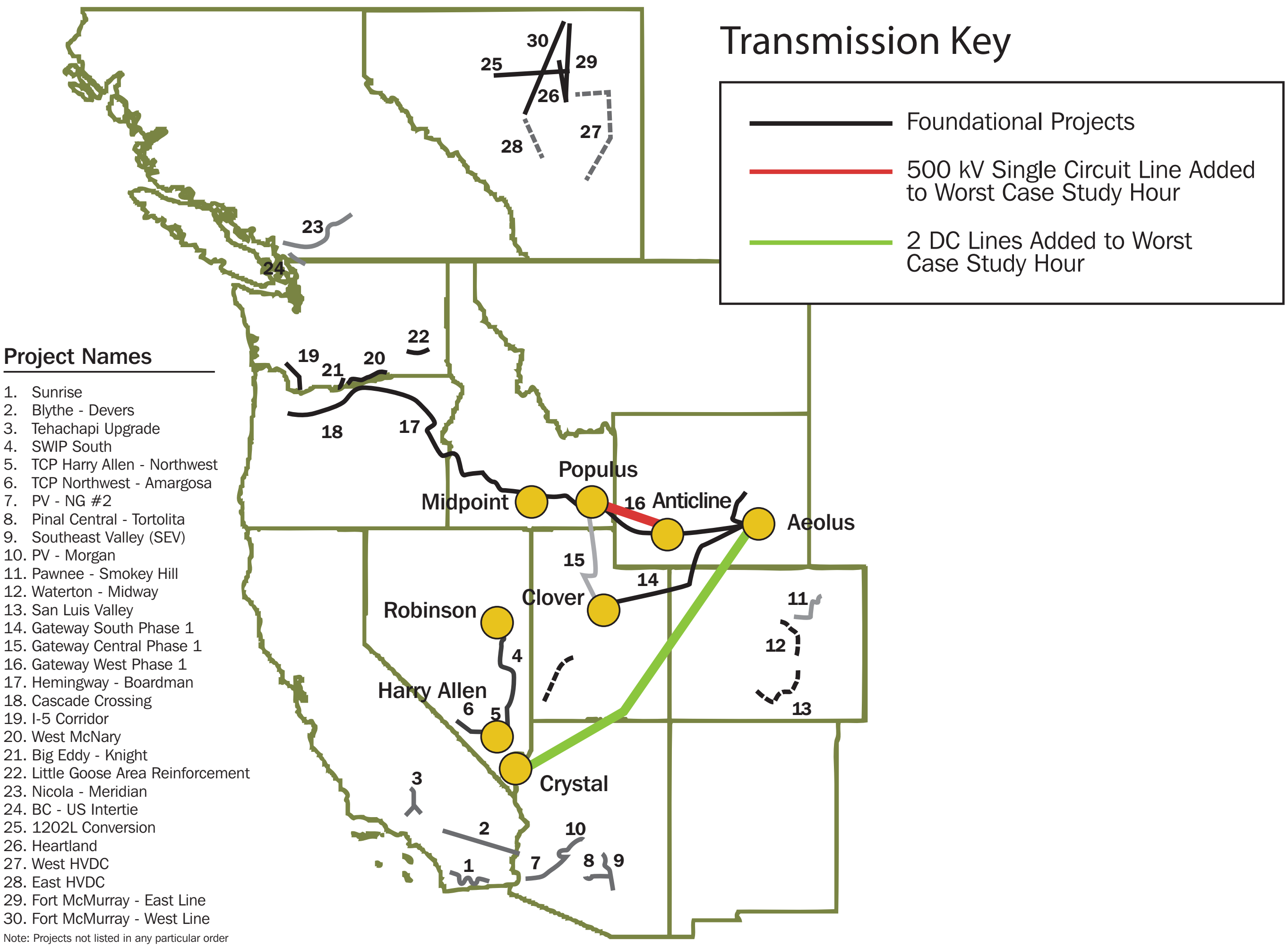
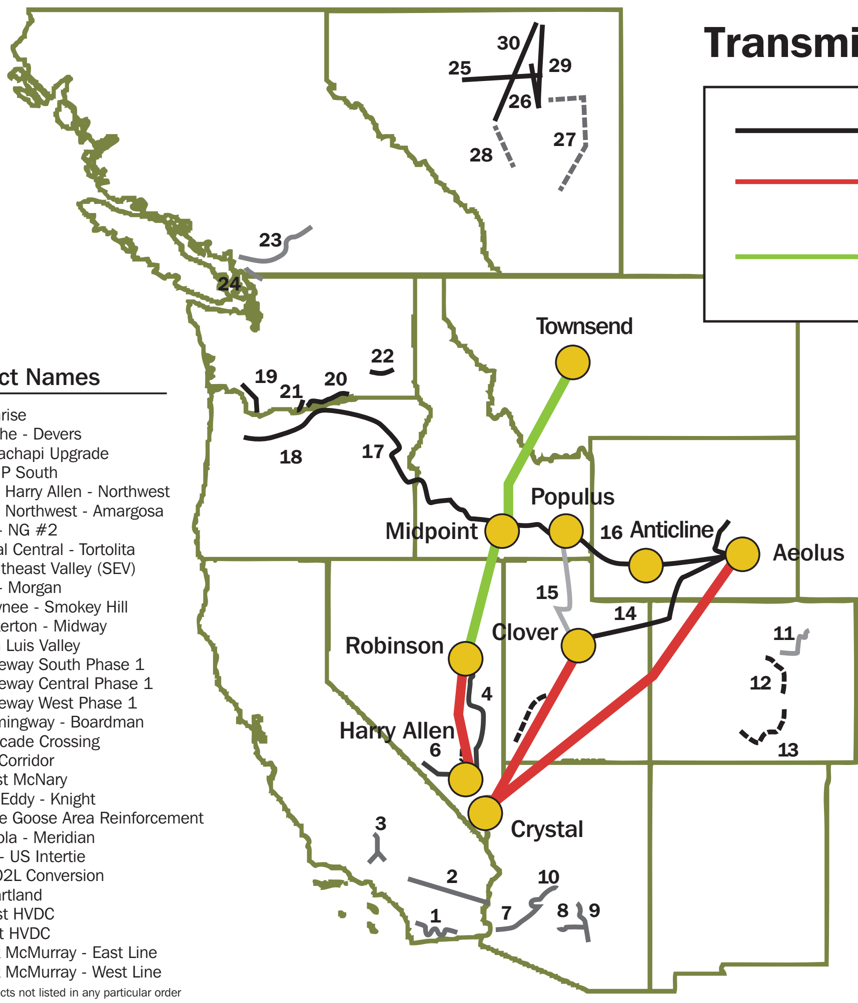



**FIGURE 6**
Scenario 1: 6,000 MW Wyoming Generic Transmission Improvements (DC Solution Option)




## Transmission Key

- Foundational Projects
- 500 kV Single Circuit Line Common to All Study Hours
- 500 kV Double Circuit Line Common to All Study Hours

### Project Names

1. Sunrise
2. Blythe - Devers
3. Tehachapi Upgrade
4. SWIP South
5. TCP Harry Allen - Northwest
6. TCP Northwest - Amargosa
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Note: Projects not listed in any particular order

**FIGURE 7**
Scenario 2: 3,000 MW
Wyoming and Montana Generic
Transmission Improvements
(AC Solution Option)

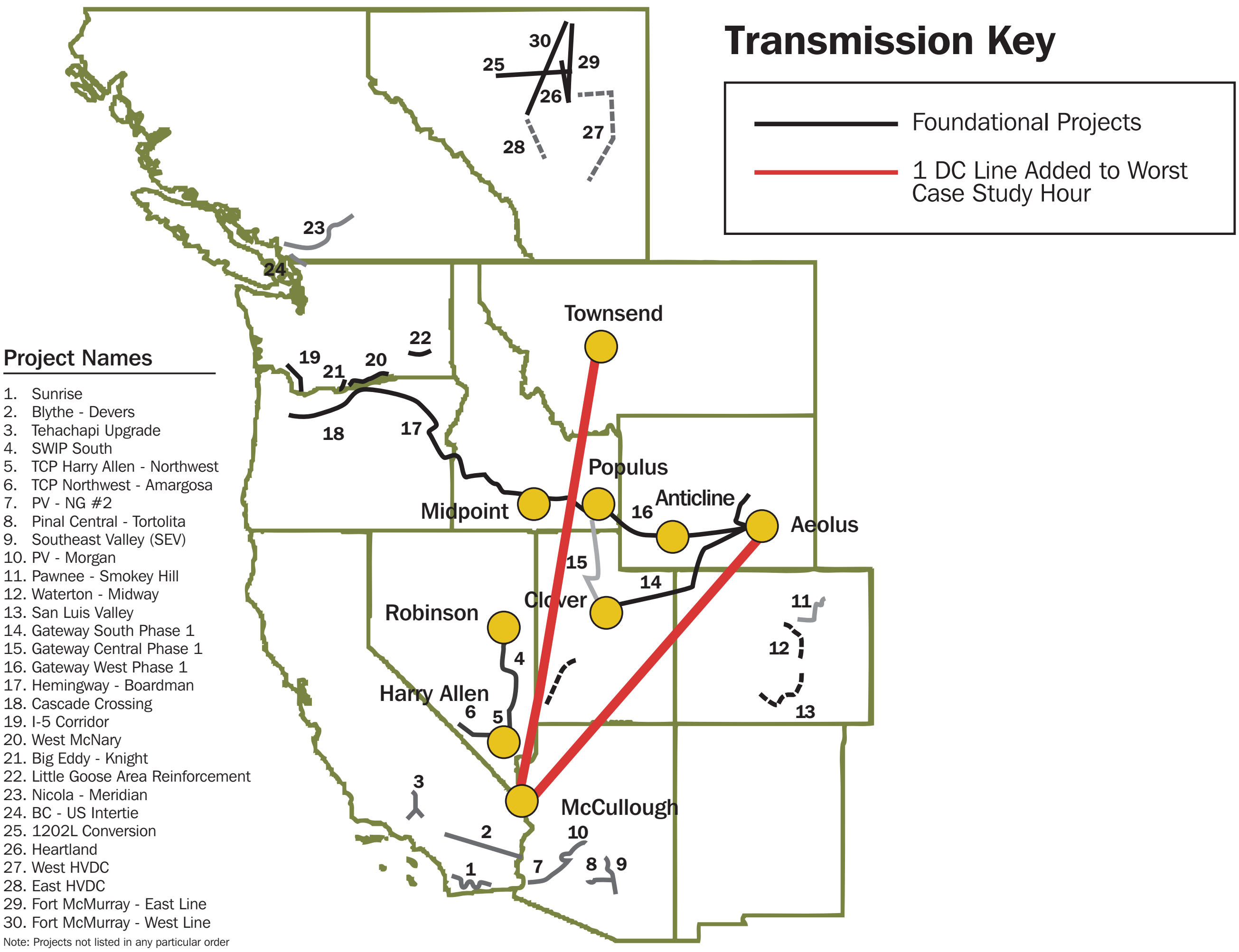



**FIGURE 8**
Scenario 2: 3,000 MW Wyoming and Montana Generic Transmission Improvements (DC Solution Option)

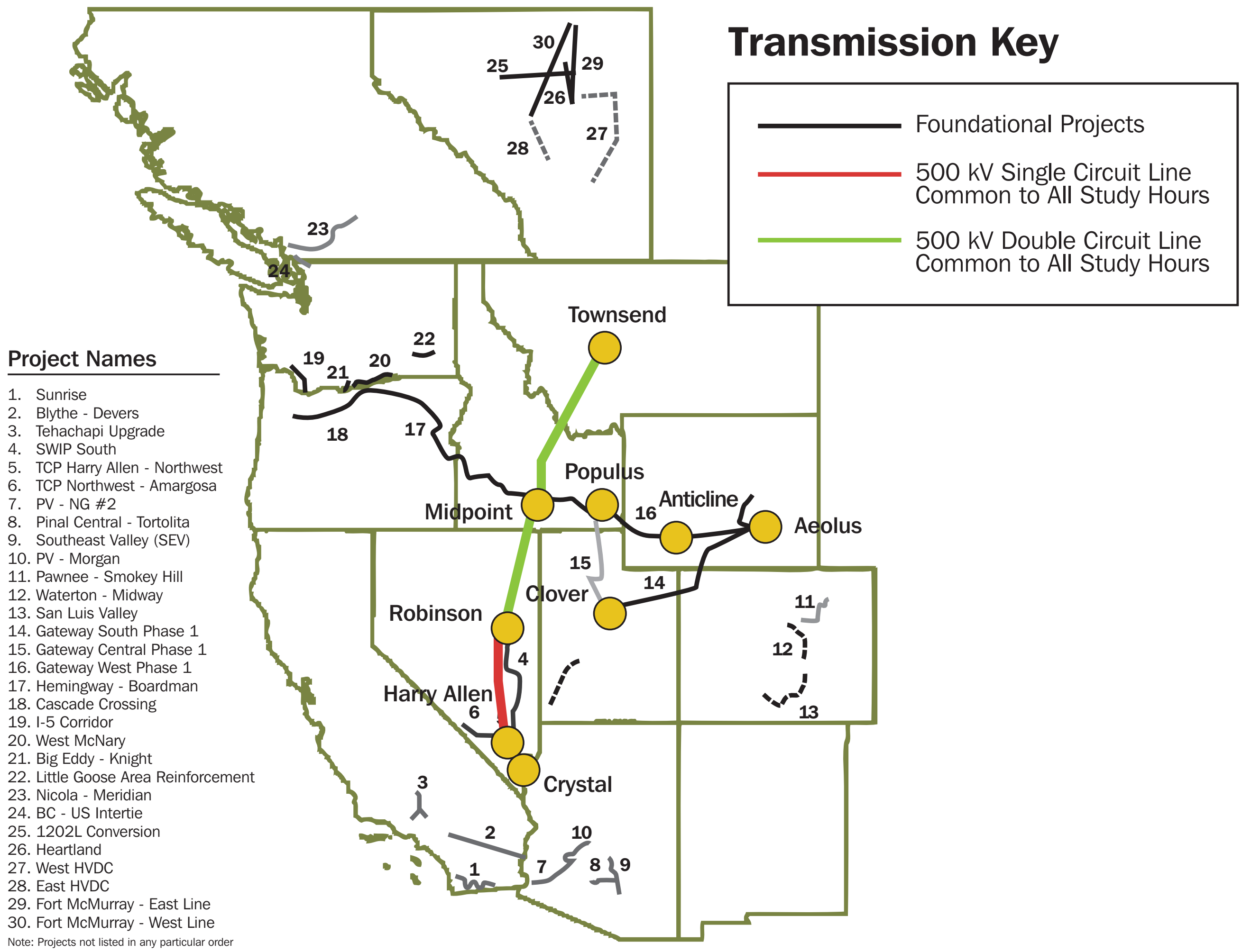
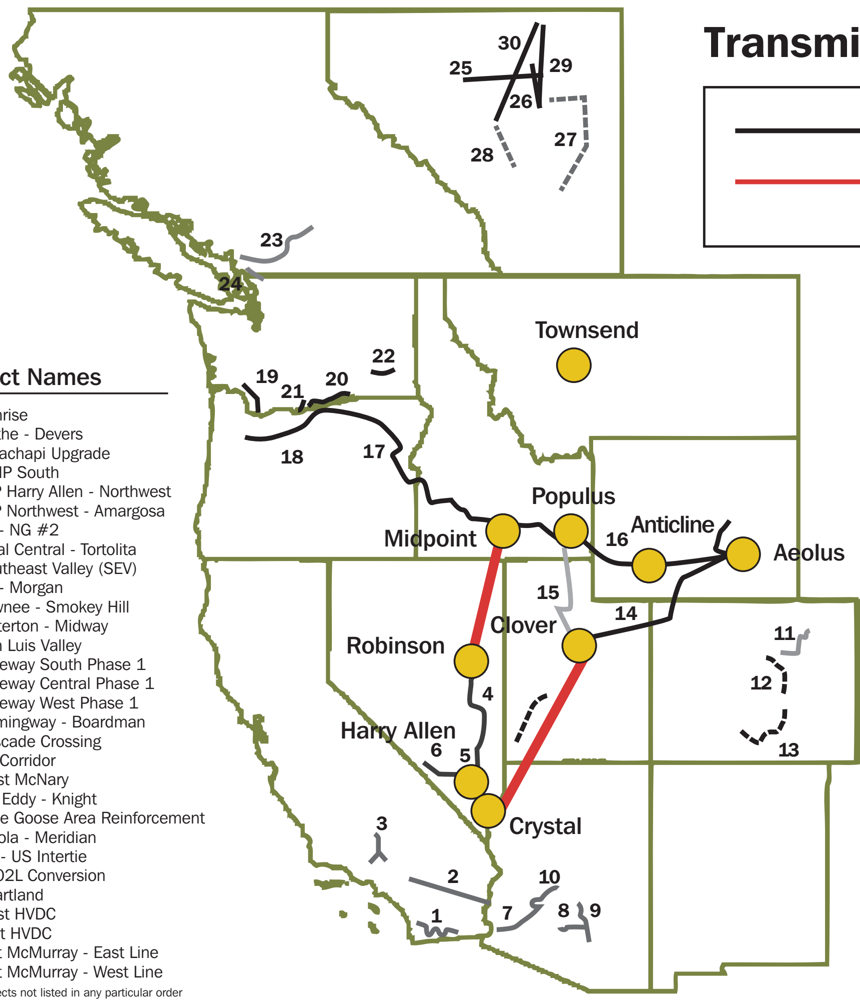



**FIGURE 9**
Scenario 3: 3,000 MW Montana Generic Transmission Improvements




## Transmission Key

- Foundational Projects
- 500 kV Single Circuit Line Common to All Study Hours

### 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
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28. East HVDC
29. Fort McMurray - East Line
30. Fort McMurray - West Line

Note: Projects not listed in any particular order

**FIGURE 10**
Scenario 4: 3,000 MW Wyoming Generic Transmission Improvements

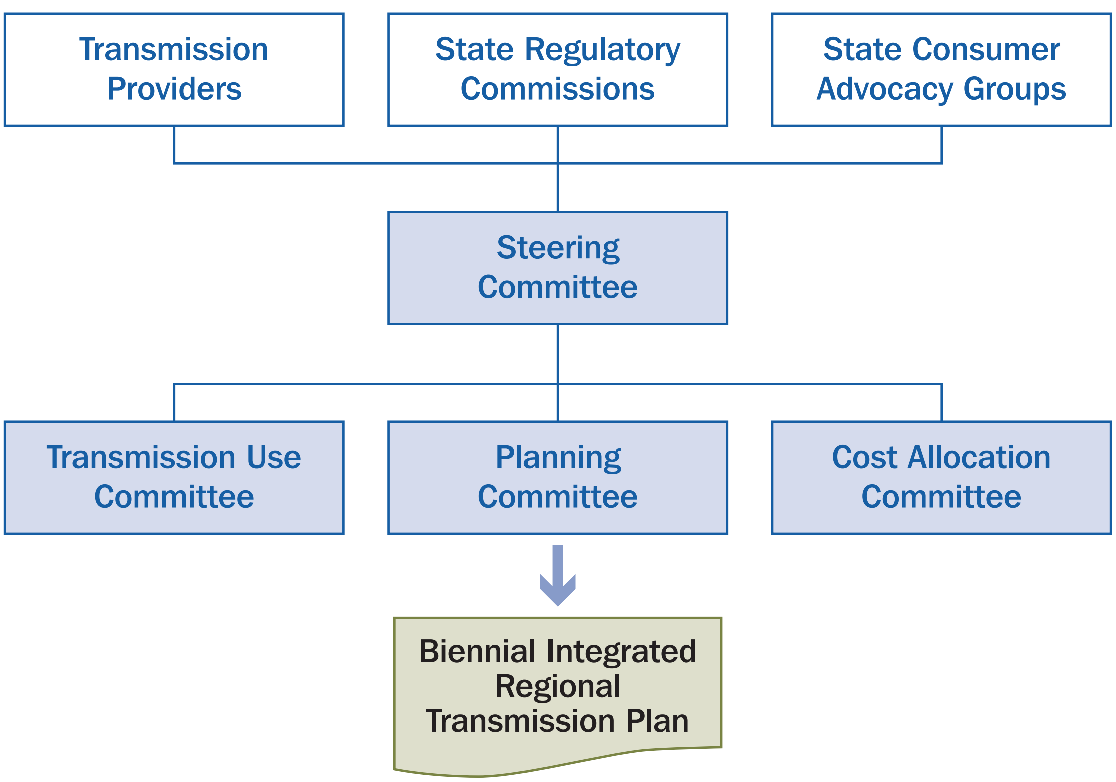
# 6. The Northern Tier Transmission Group

The Northern Tier Transmission Group fulfills FERC Order 890 requiring local transmission providers to participate in regional and subregional planning. Created in 2006, Northern Tier is a forum where all interested stakeholders, including transmission providers, customers and state regulators, can participate in planning, coordinating and implementing a robust transmission system.

NTTG focuses its efforts on the evaluation of transmission projects that move power across the subregional bulk electric transmission system, serving load in its footprint and delivering electricity to external markets. The transmission providers belonging to Northern Tier serve nearly 3.5 million retail customers with almost 3,000 miles of high-voltage transmission lines. These members provide service across much of Utah, Wyoming, Montana, Idaho and Oregon, and parts of Washington and California.

NTTG works with other entities within its footprint, the WECC Planning Coordination Committee for reliability planning, the WECC TEPPC for economic planning, and neighboring subregional planning entities.

## STRUCTURE OF THE NORTHERN TIER TRANSMISSION GROUP



## Northern Tier Members

The Northern Tier Transmission Group's organizational structure has multiple levels, as shown in the chart on page 20. Overall planning direction is provided by the Steering Committee, whose membership at publication was as follows:

- **Idaho Public Utilities Commission**
- **Oregon Public Utility Commission**
- **Montana Public Service Commission**
- **Montana Consumer Counsel**
- **Utah Public Service Commission**
- **Wyoming Public Service Commission**
- **Deseret Power Electric Cooperative**
- **Idaho Power Company**
- **NorthWestern Energy**
- **PacifiCorp**
- **Portland General Electric**
- **Utah Associated Municipal Power Systems**

The 500 kV line under construction from Mona to Salt Lake City, Utah.

On the back cover: The Hemingway 500 kV shunt reactor is assembled in Idaho.


NORTHERN TIER
TRANSMISSION GROUP