Wyoming Collector and Transmission System Conceptual Design

Presented to:

Wyoming Legislative Task Force on Wind Energy

May 27, 2010

Casper, Wyoming

Presentation Content

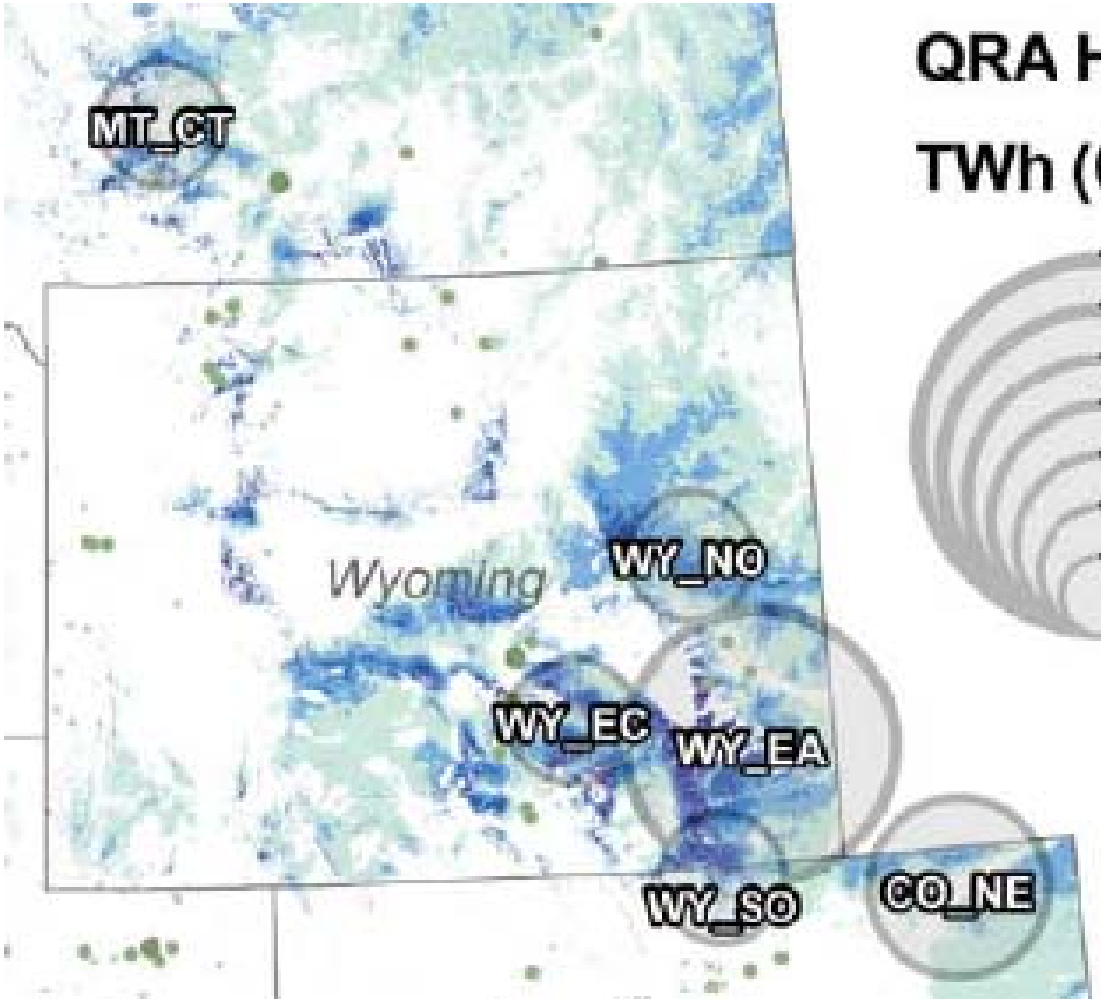
- Background
- Study Goals, Assumptions, Limitations
- Transmission Export Lines and Hubs
- The **Conceptual** Collector System
- Wind Resource Development Scenarios
- Collector System **Conceptual** Design
- Potential Use of Existing Rights-of-Way
- Preliminary Estimate of Collector System Cost
- Conclusions

Background

- Wyoming has abundant **supply** of wind, natural gas, coal
- Other States have **demand** for renewable energy
- Wyoming's transmission system is **limited**
- Multiple transmission export lines are **proposed** in Wyoming
- **Collector system**[1] could connect generation to transmission lines

[1]Wyoming Collector and Transmission System Conceptual Design Report published February 2010. Available online: http://wyia.org/documents/reports/

Background: Qualified Resource Areas (QRAs)



QRA Hub Size Guide

TWh (000s of GWh)/yr

30 - 35
25 - 30
20 - 25
15 - 20
10 - 15
5 - 10
1 - 5

NREL wind power class (50m)

3
4
5
6
7

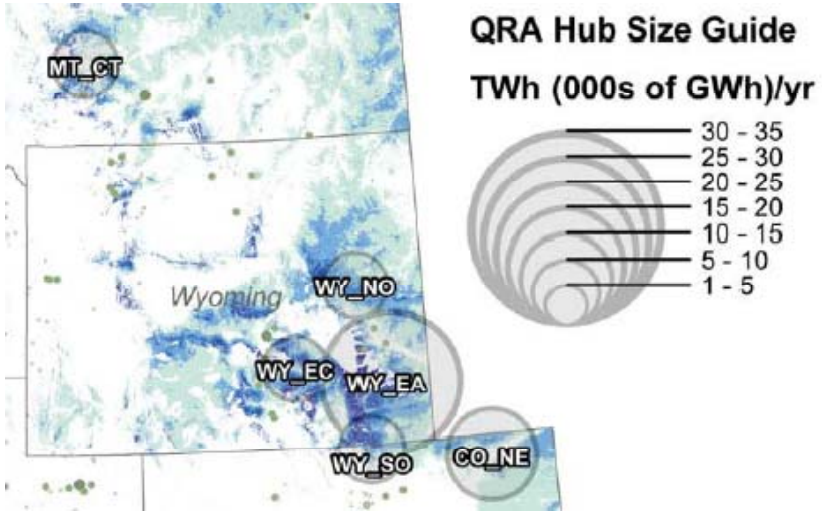
Source: WREZ Phase 1 Report 2009

Background: Qualified Resource Areas (QRAs)

- Sized in proportion to the total amount of electricity (in terawatt-hours) that could be produced over the course of one year.

- Exclude select protected (e.g., wilderness) areas but do **NOT** consider numerous environmental constraints such as sage grouse and National Forests, or construction logistics, costs, or permitting.

- Not intended to suggest that renewable development should be precluded elsewhere in the state or that significant conflicts do not occur in the vicinity of the Wyoming hubs.



Collector System Study Goals

- Develop **conceptual** design for a collector system and test reliability of connecting up to 12,000 Megawatts (MW)[1] of wind generation in Wyoming to proposed transmission export lines.

- Take a *reasonable **first look*** at **conceptual** collector designs and estimate preliminary costs.

12,000 MW (1GW) is:

- Sufficient to supply power for 6 – 12 million homes
- About four times the 2008 Annual Peak Demand in Wyoming
- Almost seven times the total capacity of Laramie River Station

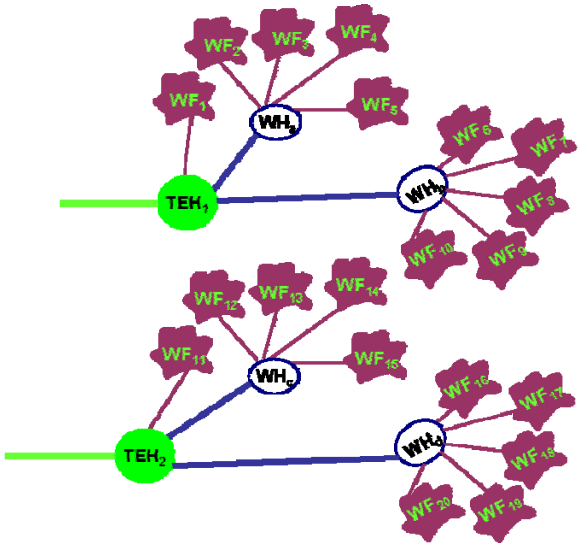
[1] 1,000 kilowatts (kW) = 1 megawatt (MW) = 1 gigawatt (GW)

Collector System Study Unknowns

- Where will wind be developed in Wyoming?
- When will wind be developed in Wyoming?
- How much wind will be developed in Wyoming?
- No similar collector systems to copy.
- Starting with **concept**.

Collector System Study Assumptions

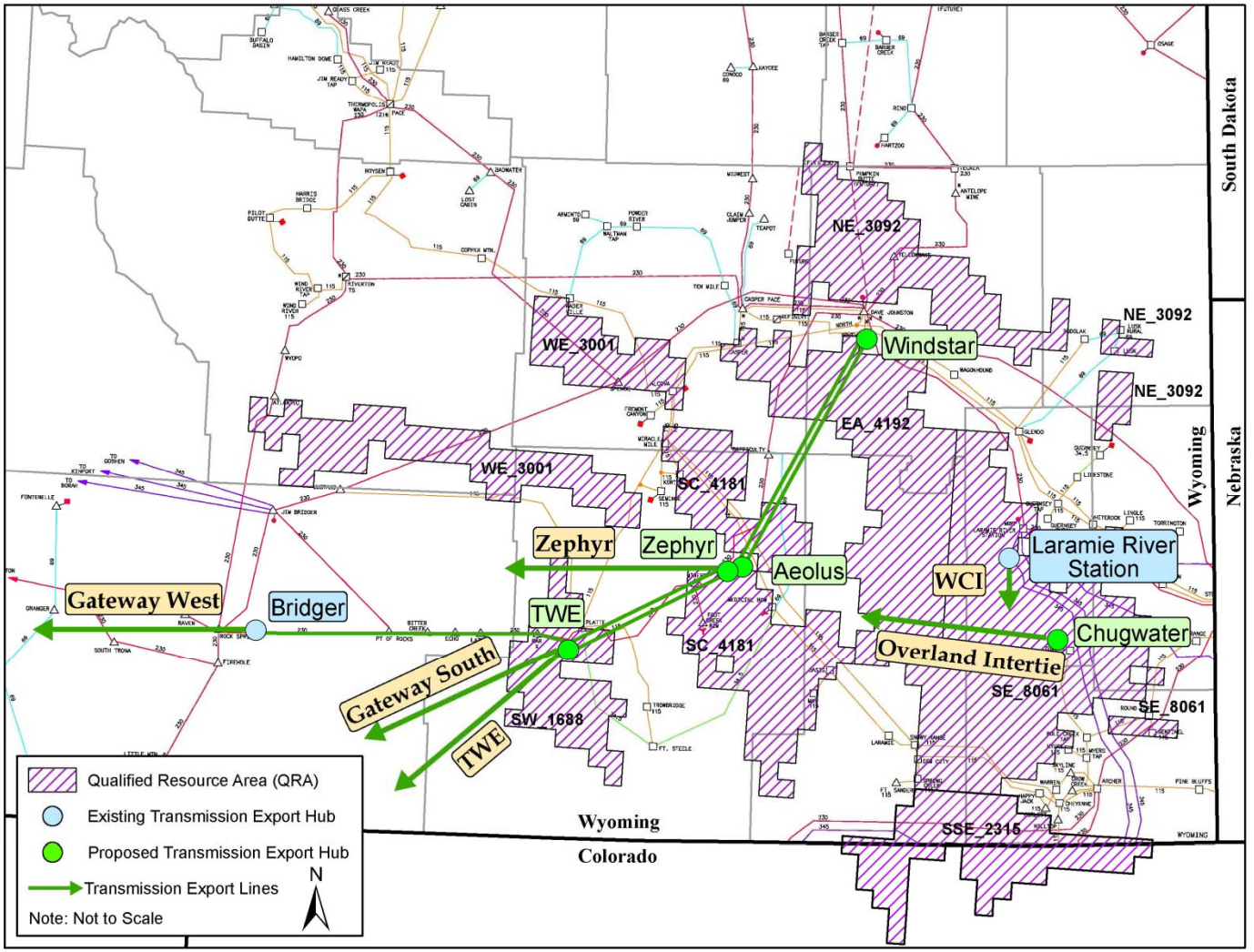
- Wind Farms (WFs) – generate 300-400 MW each
- WFs are developed within Qualified Resource Areas (QRAs)
- Wind Hubs (WHs) – collect up to 5 WFs for 2.0 GW capacity
- 40 miles of ≥230 kV line between WF and WH substations
- Transmission Export Hubs (TEHs) capacity – up to 3.0 GW
- TEH locations identified by transmission proponents



Collector System Study Limitations

- Does not predict or recommend where, when, or how much wind energy is developed.
- Wind development scenarios in the report are **conceptual.**
- Report only **illustrates** how wind could be collected once it is developed.
- Study designs are **conceptual** and do not consider on-the-ground constraints.
- Transmission lines from WFs to WHs, and from WHs to TEHs, are **conceptual** and assumed to be straight lines; actual routes and distances may vary.
- No consideration given to transmission line routing which must consider Right-of-Way requirements, costs, environmental and land use constraints, and other factors.

Transmission Export Lines – Starting Point for Collector System Study

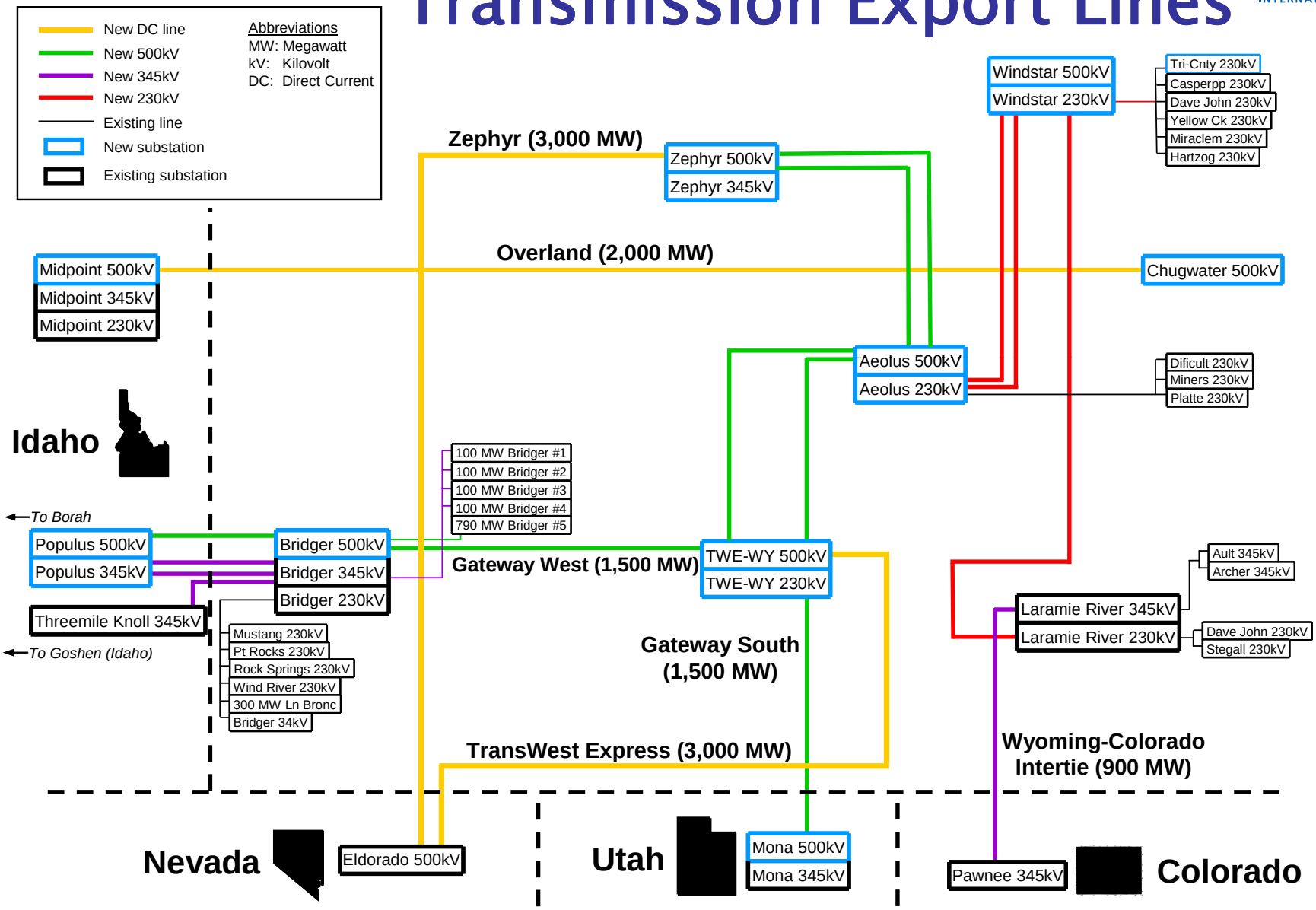


Transmission Export Lines - Capacity

Transmission Project	Capacity (Megawatts)
Gateway South *(PacifiCorp)*	1,500
Gateway West *(PacifiCorp)*	1,500
Overland Intertie *(LS Power Development, LLC)*	2,000
Wyoming–Colorado Intertie *(LS Power Development, LLC)*	900
Trans West Express *(Anschutz Corporation)*	3,000
Zephyr *(TransCanada)*	3,000
Total	11,900

NOTE: Capacities are based on thermal ratings and do not represent simultaneous system rating. Capacity for each project provided by transmission proponents. Capacities are representative values which may change based on final path rating.

Transmission Export Lines

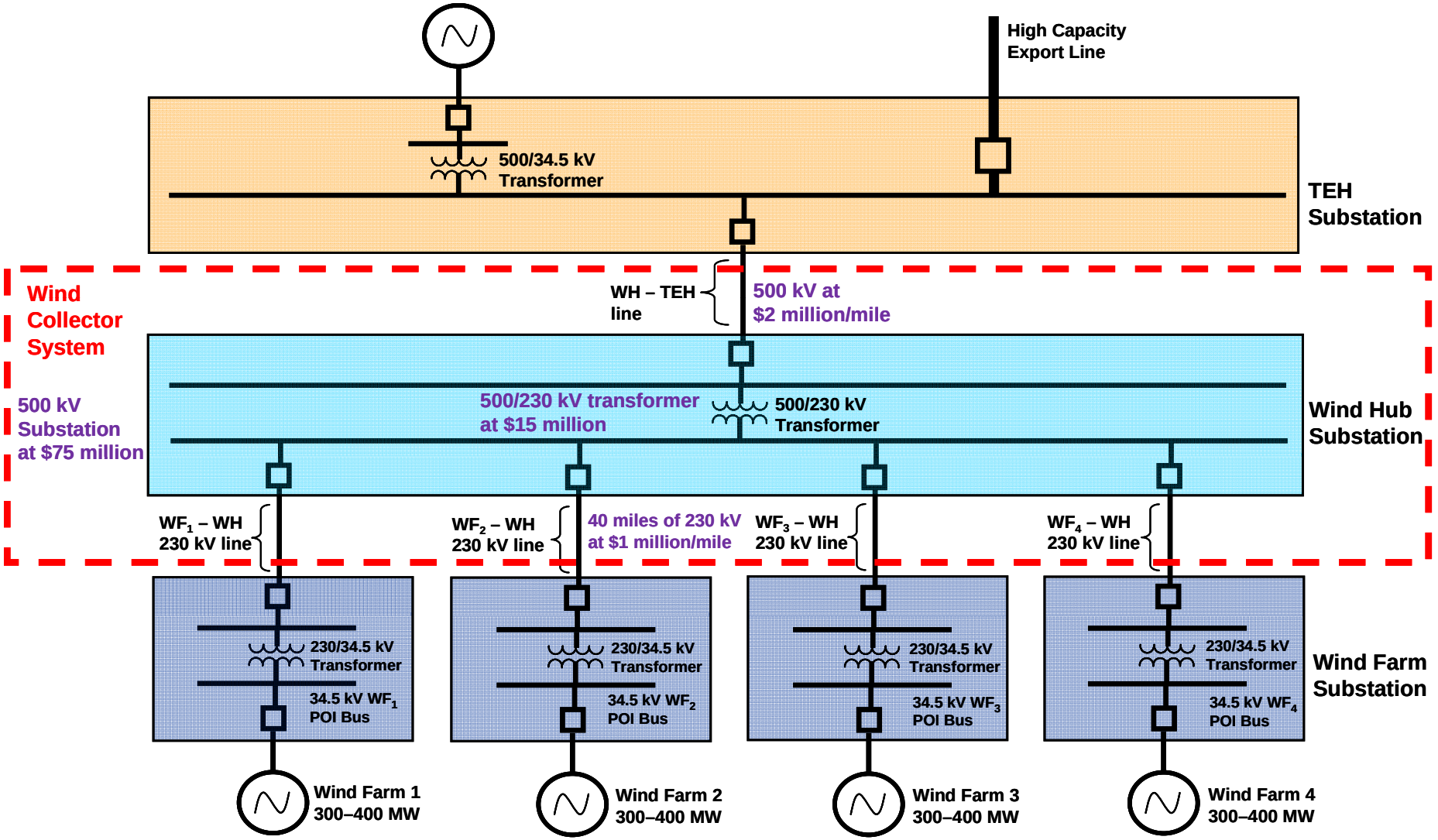


Transmission Export Hubs - Capacity

Transmission Export Hub		TEH Capacity Range (MW)
Name	Number	
Windstar	1	0 - 800
Laramie River Station	2	0 - 900
Chugwater	3	0 - 2,000
Aeolus	4-a	0 - 3,000
Zephyr	4-b	0 - 3,000
TWE	5	0 - 3,000
Bridger	6	0 – 1,500

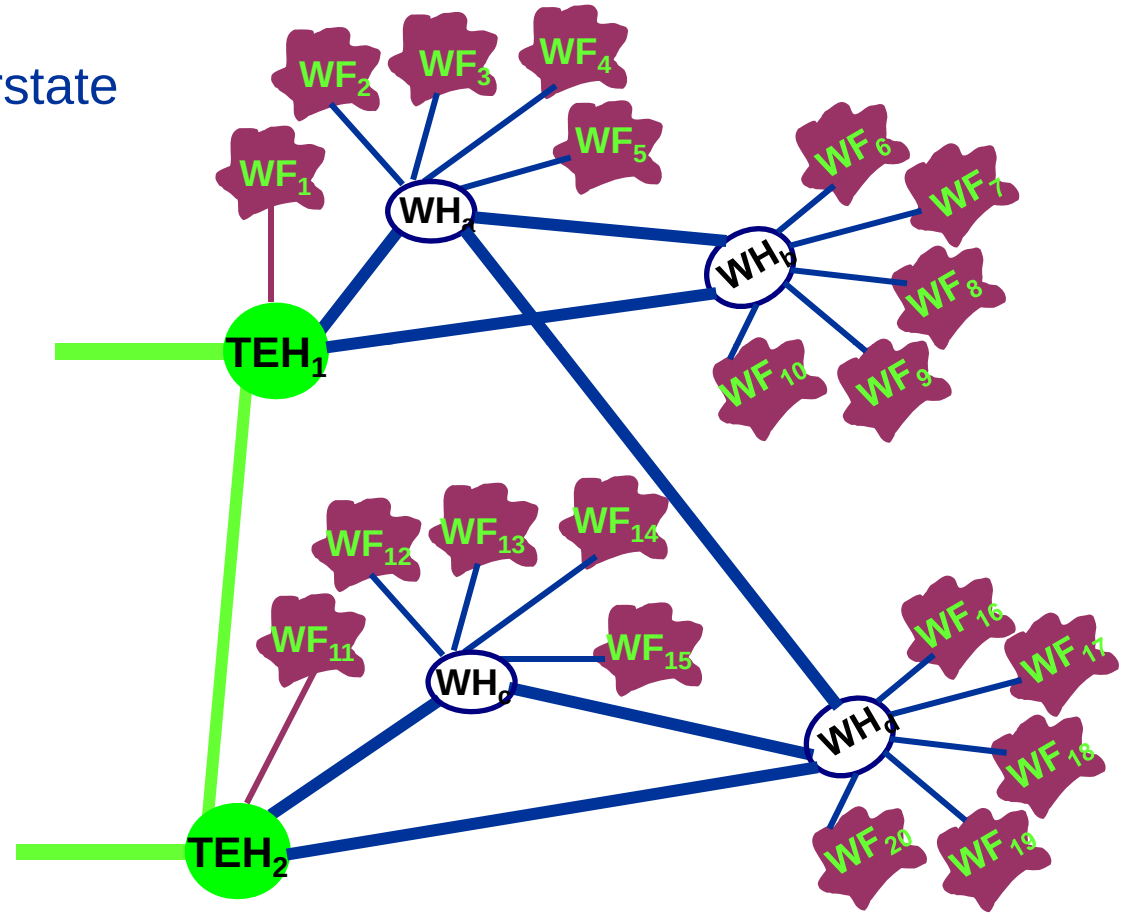
MW Megawatts
TEH Transmission Export Hub
TWE TransWest Express, LLC

The Collector System – A Concept



The Collector System – A Concept

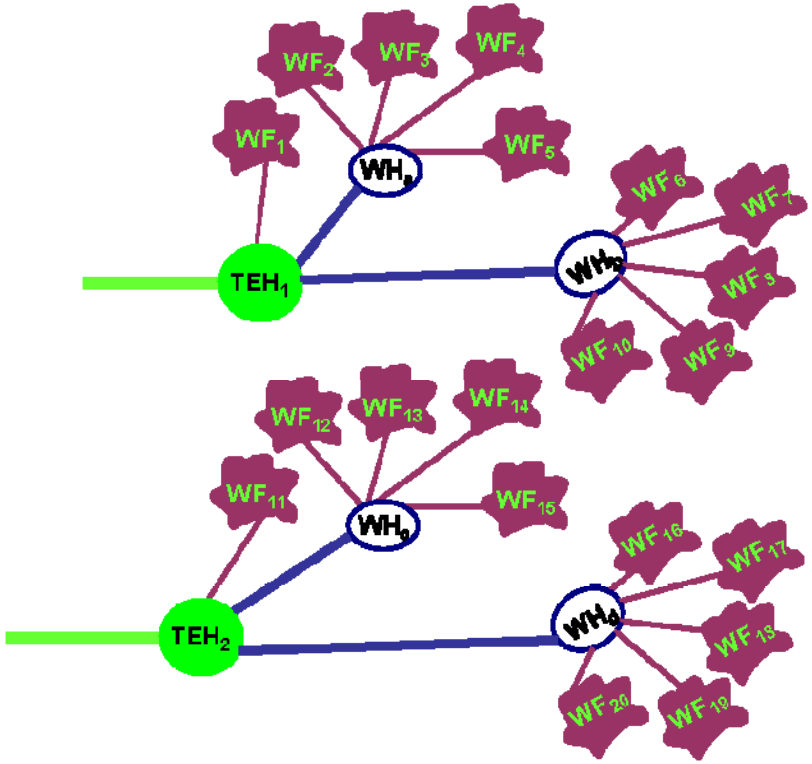
- Connects wind farms to interstate transmission lines



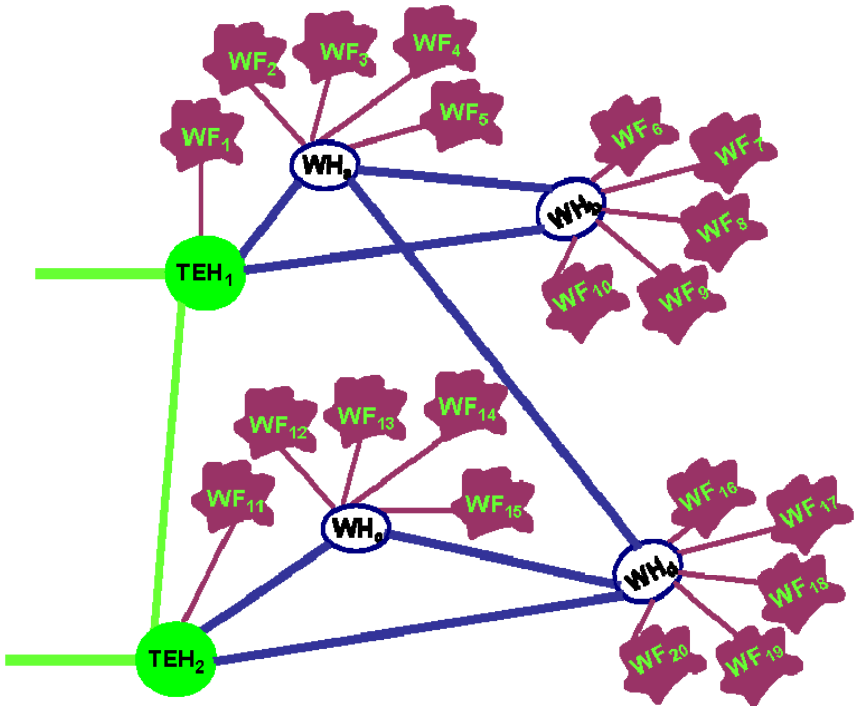
Note: **Blue** components are included in collector system cost estimate.

Two Conceptual Collector System Designs

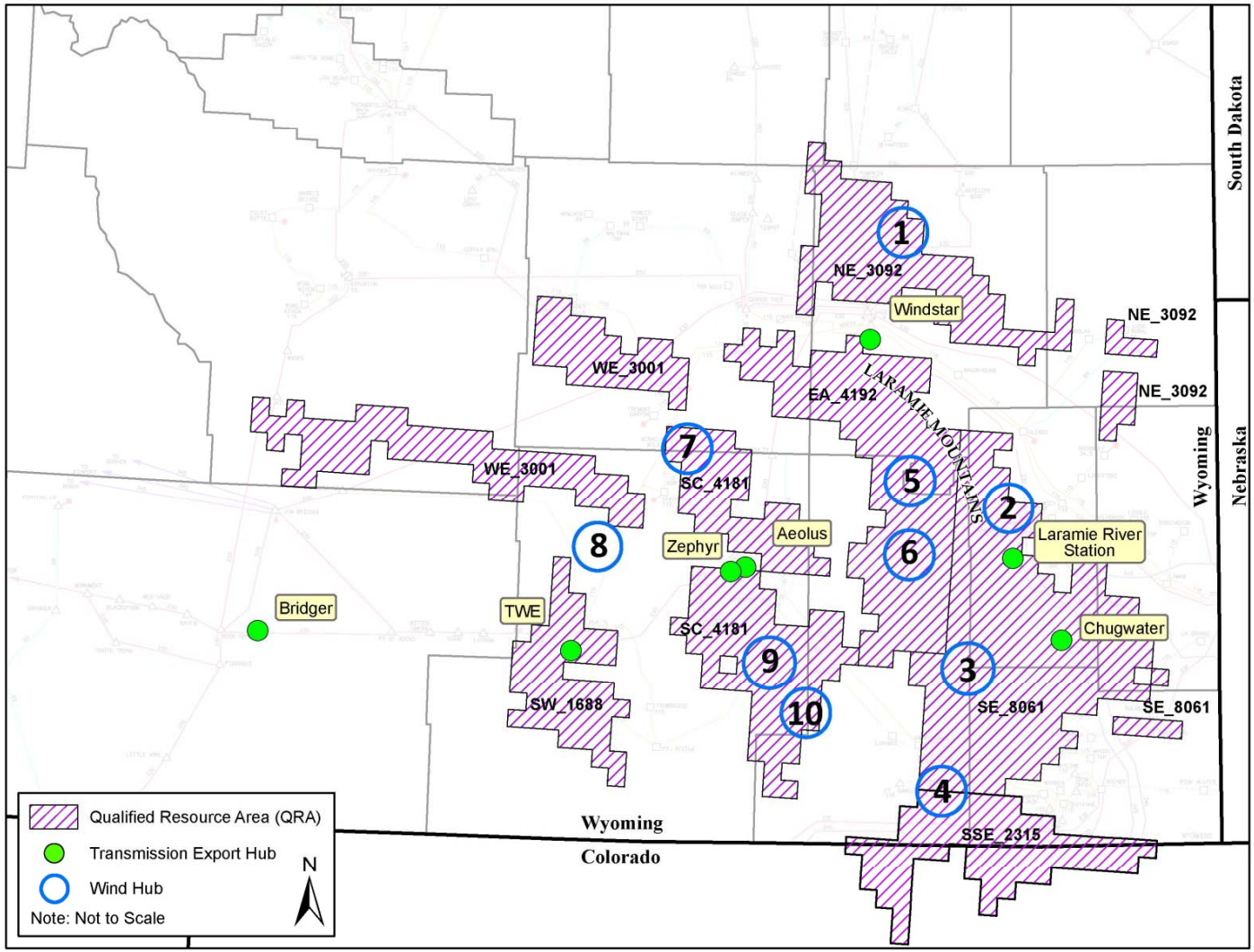
Radial



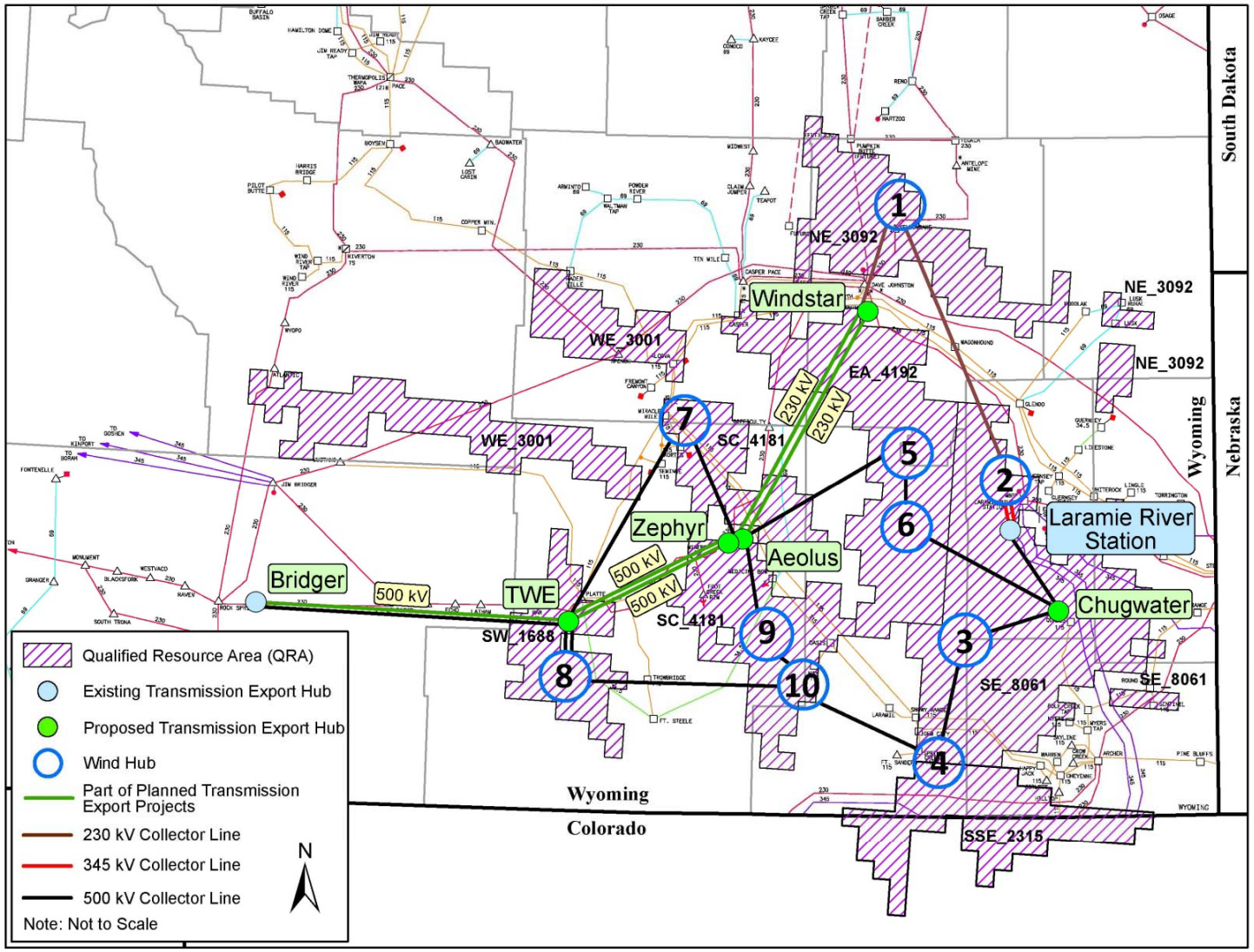
Networked



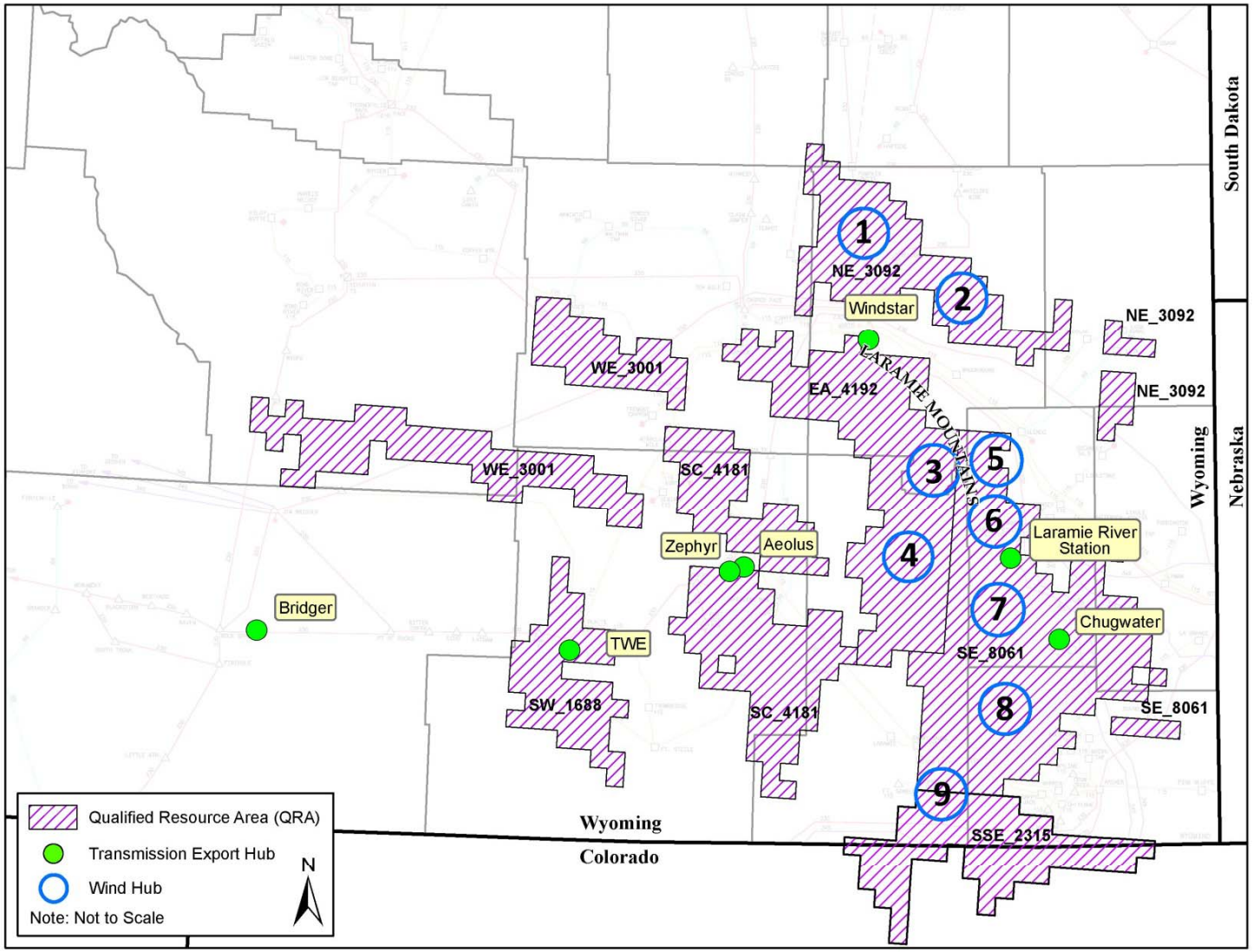
Wind Resource Development Scenario #1



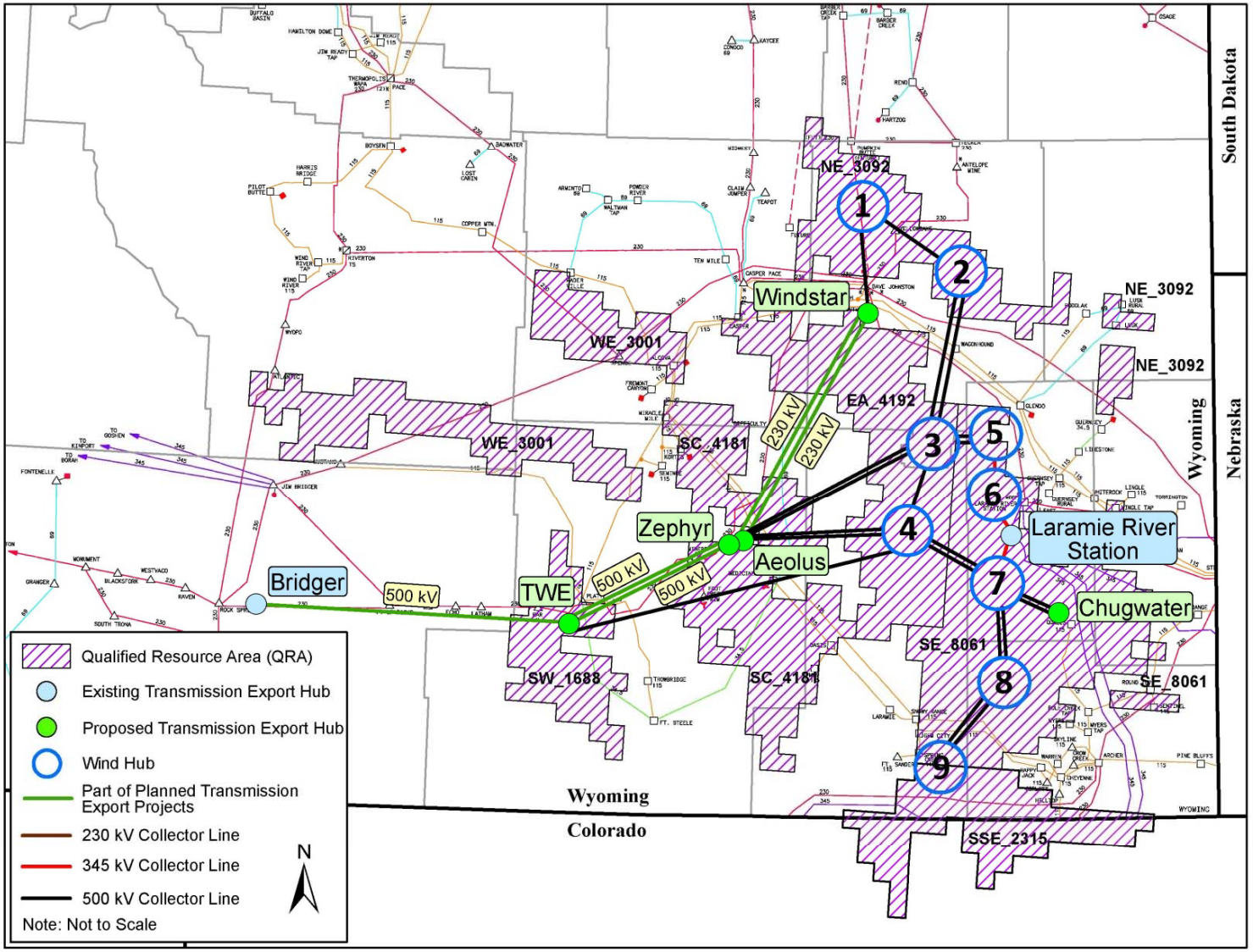
Wind Resource Development Scenario #1



Wind Resource Development Scenario #2



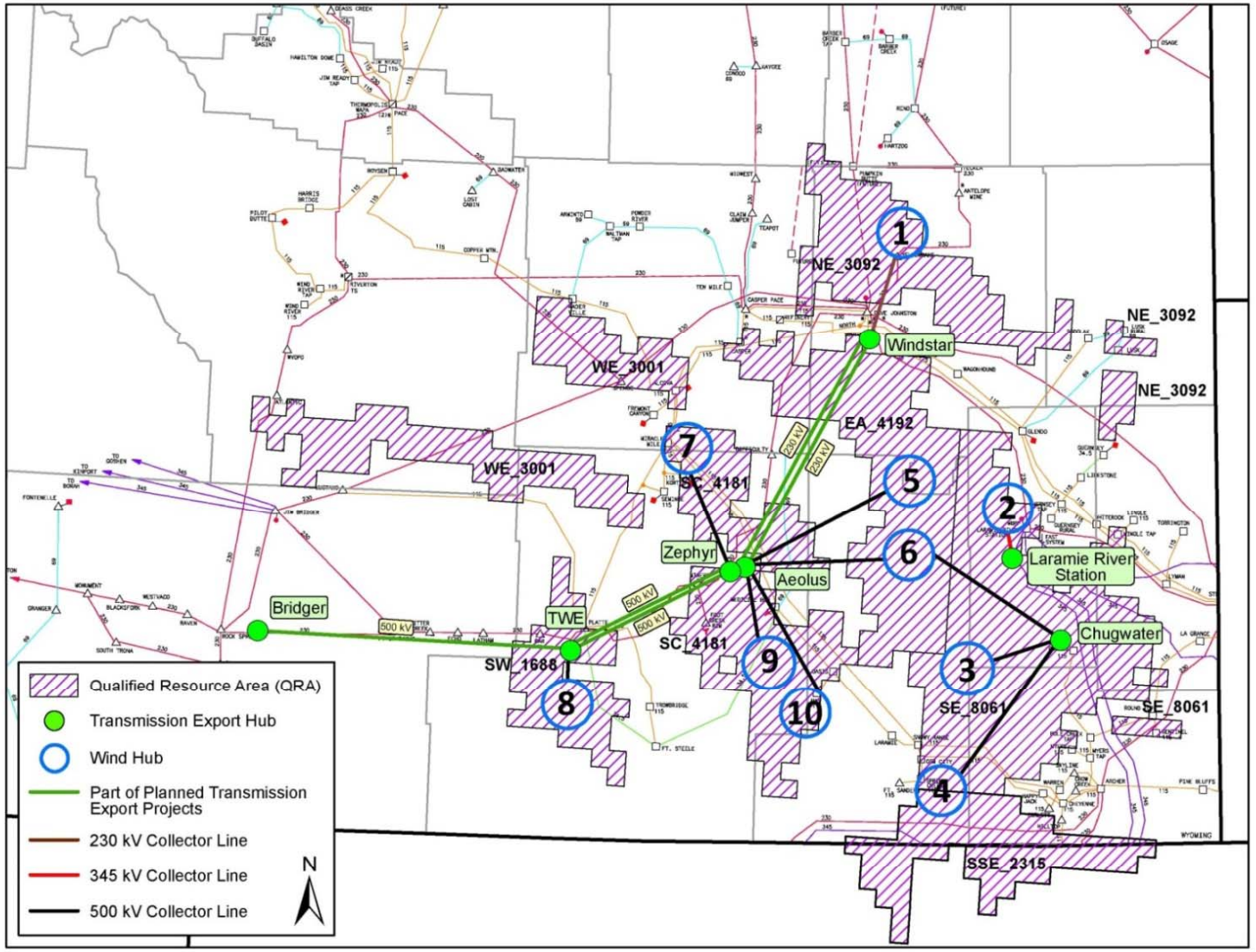
Wind Resource Development Scenario #2



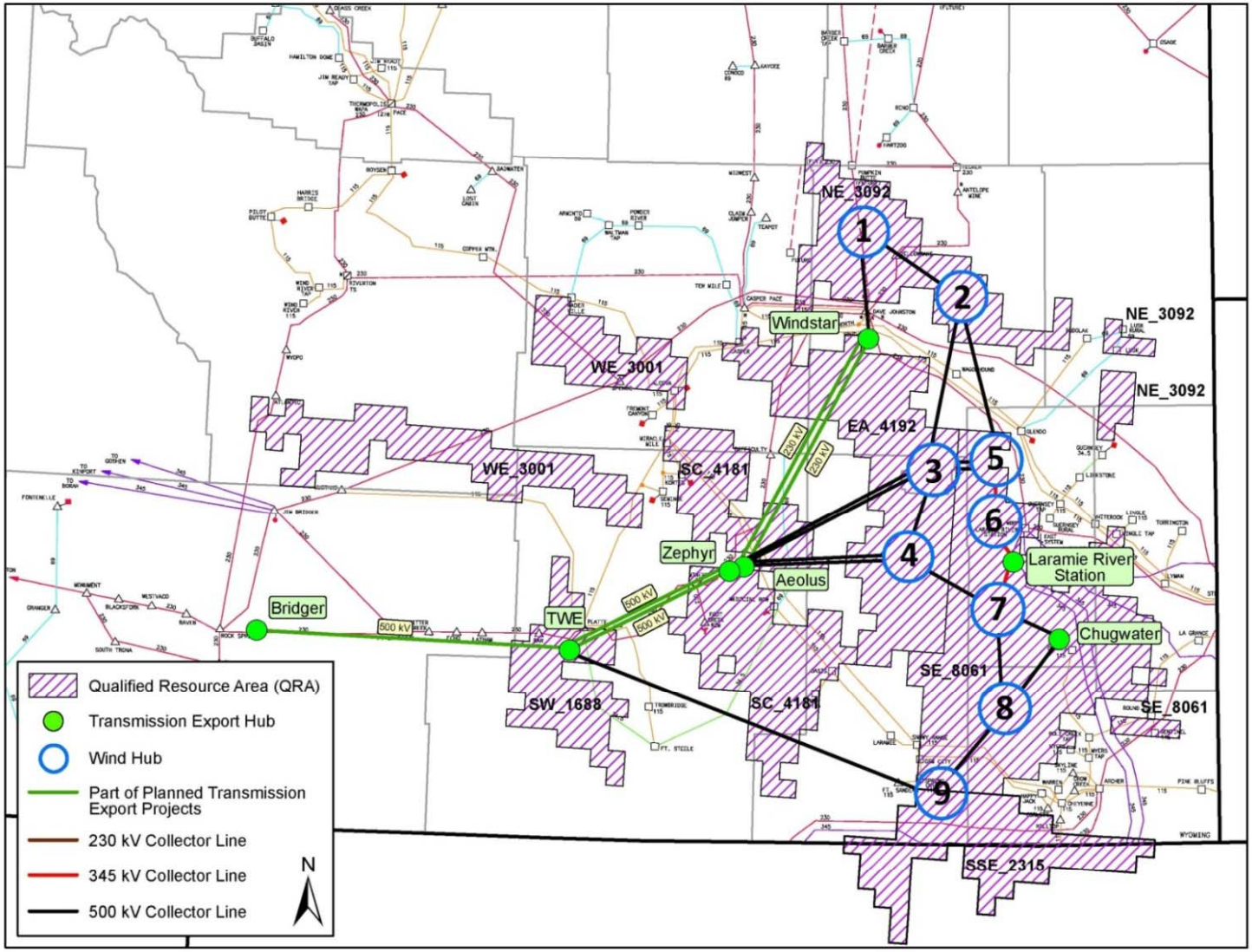
Resource Development Scenarios

Wind Development Area	Resource Scenario #1	Resource Scenario #2
South Central	6,400	0
North East	800	2,400
East Central	2,400	2,400
East of Laramie Range	1,600	6,400
South East Wyoming Border	800	800
TOTAL	12,000	12,000

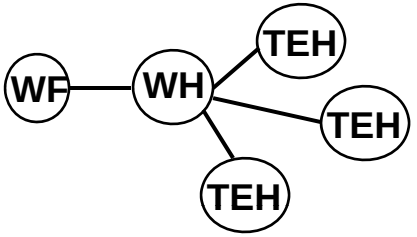
Illustrative Collector System Design - Radial



Illustrative Collector System Design - Networked



Conceptual Design Type Characteristics

Characteristics	Single Circuit–Radial	Double Circuit–Radial	Networked
Pathways			
Cost	Lower	Higher	Higher
Reliability	Lower	Medium (common corridor outages still very likely)	Higher
Market Liquidity (Access to TEHs)	Lower (only to one TEH)	Lower (only to one TEH)	Higher (multiple TEHs)

Notes:
Single circuit – single line
Double circuit – two parallel lines
Can have two lines (circuits) on same tower but ICF study assumes two separate towers for double circuit.

Potential Use of Existing Rights-of-Way

Line No.	Collector System Transmission Line	Possibility to use any existing ROW?	Existing ROW
1	230 kV WH1 to Windstar	Yes	230 kV Yellow Cake to Dave Johnston
2	230 kV WH1 to WH5	No	-
3	230 kV WH2 to WH5	No	-
4	500 kV WH5 to WH6	No	-
5	500 kV WH5 to Aeolus	No	-
6	230 kV WH6 to LRS	No	-
7	345 kV WH2 to LRS	Yes	230 kV Ault to LRS
8	500 kV WH6 to Chugwater	No	-
9	500 kV WH3 to Chugwater	No	-
10	500 kV WH3 to WH4	No	-
11	500 kV WH4 to WH10	Yes	115 kV Spring Creek to Gem City to Snowy Range to Laramie to Oasis
12	500 kV WH10 to WH9	Yes	115 kV May115 to Oasis to Medicine Bow
13	500 kV WH10 to WH8	No	-
14	500 kV WH8 to TWE-WY	Yes	34.5 kV Ft. Steele to Platte
15	500 kV WH9 to Aeolus	Yes	115 kV Medicine Bow to Miracle Mile
16	500 kV WH7 to TWE-WY	Yes	115 kV Miracle Mile to Platte
17	500 kV WH7 to Aeolus	Yes	115 kV Medicine Bow to Miracle Mile

kV	Kilovolt	ROW	Right-of-Way
LRS	Laramie River Station	TWE	TransWest Express, LLC
No.	Number	WH	Wind Hub

Preliminary Estimate of Collector System Cost

Collector System Configuration	Design Type		Cost Estimates (nominal $ billions)		Approximate Total Line Miles	
			Resource Scenario #1	Resource Scenario #2	Resource Scenario #1	Resource Scenario #2
Radial	Single Circuit		$2.48	$2.84	1,460	1,709
	Double Circuit		$3.34	$3.90	1,840	2,178
Networked WHs	Minimal Double Circuit		$2.93	$3.39	1,683	1,914
	Multiple Double Circuit		$3.13	$3.52	1,508	1,666
Networked WHs and TEHs	Minimal Double Circuit	Version 1	$3.07	$3.55	1,721	2,039
		Version 2	$3.14	$3.75	1,530	1,832
	Multiple Double Circuit		$3.35	$3.89	1,604	1,903

TEH Transmission Export Hub
WH Wind Hub

Note: Mileage estimates are approximate, and based on straight line calculations. The estimates do not account for land use, environmental, and other constraints.

Conclusions

- Reliable collector systems capable of transferring 12 GW of wind out of Wyoming were designed in concept.

- The designed systems will withstand rigorous contingencies of the collector network elements without significant overloads on the existing network.

Thank You

Robert J. Henke
ICF International
303-792-7810
rhenke@icfi.com