Wyoming Wind Collector System and Integration Study

Presented to

Wyoming Infrastructure Authority
Board of Directors

Study Conducted for

Wyoming State Energy Office and WIA

Jackson, WY

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Outline

- Phase 1 Purpose
- Phase 1 Background
- Phase 1 Results
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Phase 1 Purpose

- Determine whether a reliable collector system could be designed.

- Given:
  - Need to collect up to 12 gigawatts of wind generation
  - Need to connect 6 extra-high voltage transmission lines

- Without:
  - Picking winners and losers (i.e., where will wind be developed)
  - On the ground analysis

Phase 1 Background

Proposed Transmission Line	Capacity (Megawatts)
Gateway South (PacifiCorp)	1,500
Gateway West (PacifiCorp)	1,500
Overland Intertie (LS Power)	2,000
Wyoming-Colorado Intertie (LS Power)	900
TransWest Express (Anschutz Corporation)	3,000
Zephyr (TransCanada)	3,000
TOTAL	11,900

Phase 1 Results

- A reliable collector system can be designed
  - Collect up to 12 gigawatts of wind
  - Connect to 6 extra-high voltage transmission lines
  - Rough costs: $2.5 to $4.0 billion ($210 to $330 per kW)
    - May vary widely depending on design and where/how wind is developed

Subsequent events, including a third drawing of the Wyoming Sage Grouse Core Area Map; continued development of transmission projects in the State; and the recent contracting of transmission capacity via the open season process indicate that a more compact, and less expensive, collector system may be adequate.

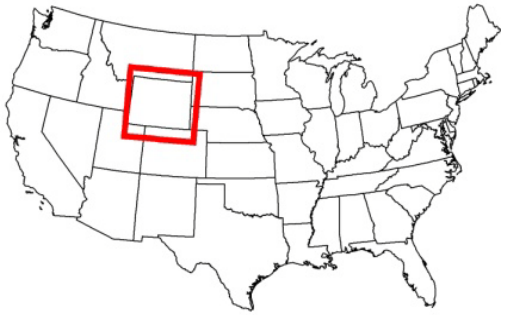
Loyd Drain, Wyoming Infrastructure Authority

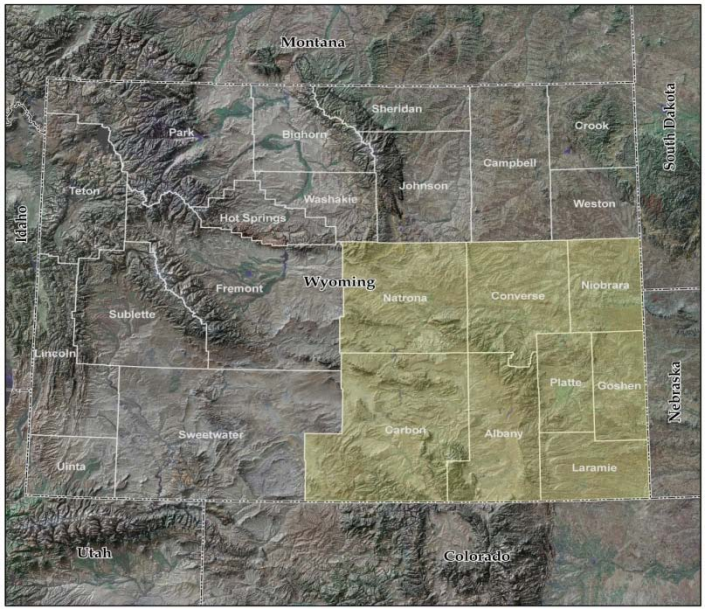
Phase 2 Objectives

- Location
  - Develop energy corridor constraints/opportunities criteria (Task 1)
- Financing
  - Assess financing options for Wyoming wind collector system (Task 2)
- Backup
  - Analyze backup scenarios for wind firming (Task 3)

Task 1 – Energy Corridor Constraints and Opportunities

- Analyzed geospatial data for 8 counties in southeast Wyoming
- Created protocol for prepare a contraint/opportunity map
- Under separate contract ICF created map





Task 2 – Financing Options for Wyoming Wind Collector System

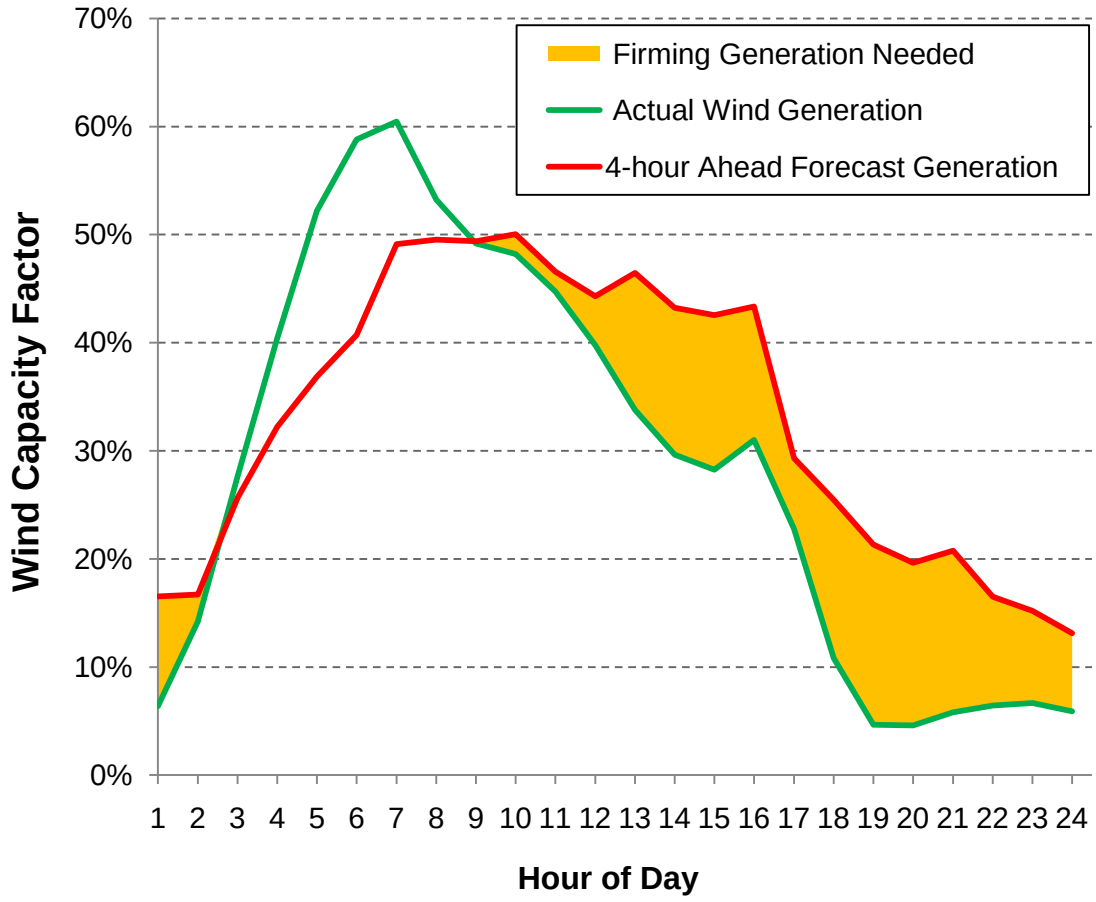
- Evaluated 3 general types of financing options
  - Privately financed
  - Publically financed
  - Public-private partnerships
- Large Wyoming collector system will likely need public support
- Best financing alternative is likely a public-private partnership

Task 3 – Wind Firming Scenarios

- Focused on evaluating capital costs associated with wind firming options, including:
  - Determining the amount of backup capacity required
  - Preparing capital cost estimates for physical assets
  - Developing scenarios to assess the capital cost of backup options

Definition of “Firming Generation” and Backup Capacity Requirements

- If actual wind generation falls below the forecast, backup capacity is needed to make up the difference – this is “firming” generation.



Results of Backup Analysis

- Historic differences between forecast and actual wind generation show a backup capacity equal to 25.8% of wind nameplate capacity.
  - 25.8% of 12,000 MW = 3,096 MW

- Backup capacity is a relatively small portion of total project costs.

Options for Wind Backup Capacity

1. Gas-fired combustion turbines (Gas CTs)
2. Electricity storage technologies

- New Gas CTs may require new natural gas pipeline and storage capacity.
- Backup capacity and supporting infrastructure may be in Wyoming or California.

Developing the Scenarios for Wind Firming

Type of Backup Capacity	*Location of Backup Capacity*	*New or Existing Infrastructure*	*Location of Gas Infrastructure*
Gas CT	Wyoming	Gas CT	Wyoming
		Gas Pipeline	
	California	Gas Storage	California
Electric Storage	Wyoming	New, Low Cost Electric Storage	
	California	New, High Cost Electric Storage	

Matrix of Scenario Options

			Scenario Number									
			1	2	3 A	3 B	3 C	3 D	4 A	4 B	5 A	5 B
Type of Backup	Natural Gas		X	X	X	X	X	X				
	Electric Storage								X	X	X	X
Combustion Turbine	WY	New	X	X								
		Existing										
	CA	New					X	X				
		Existing			X	X						
Gas Storage	WY	New	X									
		Existing										
	CA	New		X	X	X	X	X				
		Existing										
Gas Transmission	WY	New	X	X		X		X				
		Existing			X		X					
	CA	New		X		X		X				
		Existing			X		X					
Electric Storage	WY	New							X	X		
		Existing										
	CA	New									X	X
		Existing										

Capital Costs for Backup Capacity

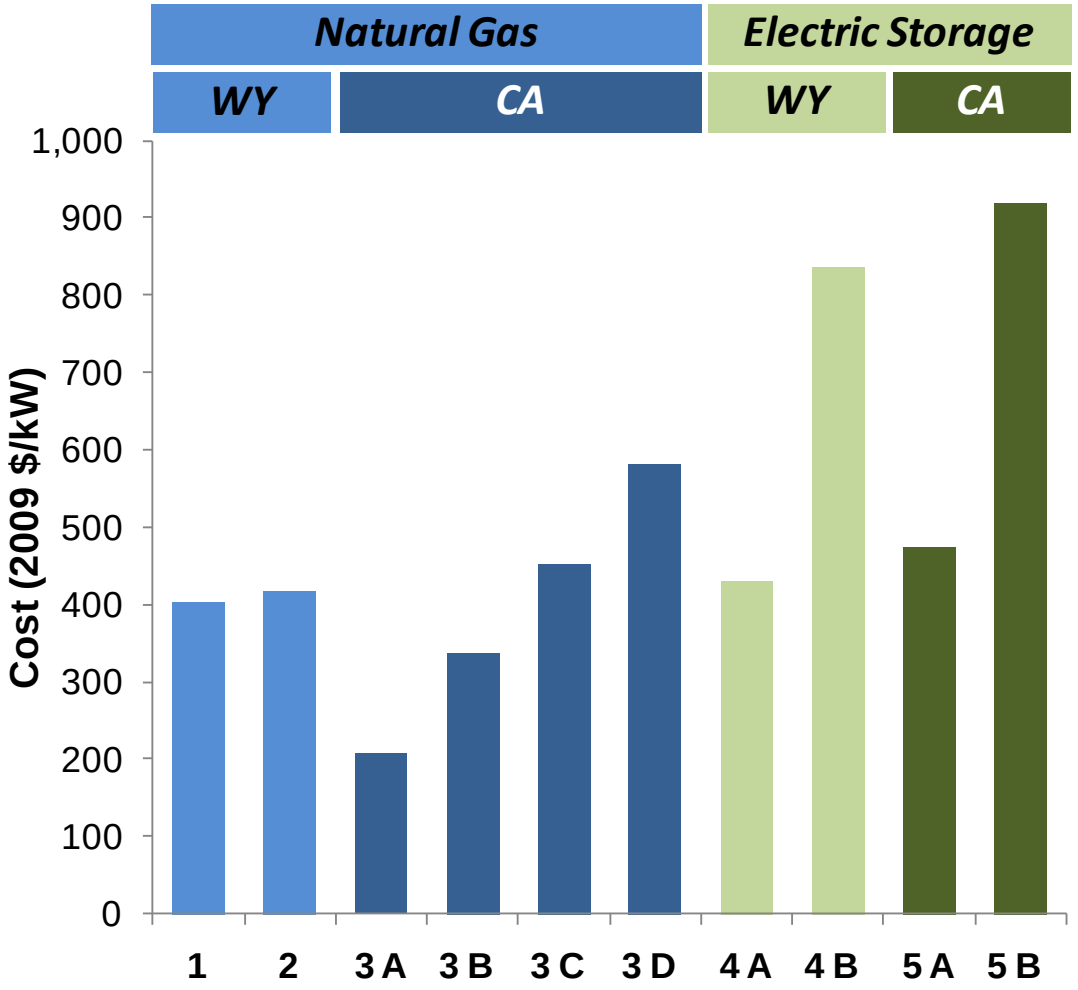
Cost Element	*Wyoming New Build*	*California New Build*
Gas CT ($/kW)	$766 / kW	$845 / kW
Gas Pipeline ($/inch-mile)	$48,960 / inch-mile	$88,740 / inch-mile
Gas Storage (million$/Bcf)	$7 million / Bcf	$10 million / Bcf
Electric Storage Low-cost Mix ($/kW)	$1,566 / kW	$1,733 / kW
Electric Storage High-cost Mix ($/kW)	$3,135 / kW	$3,465 / kW

Breakdown of System Capital Costs

Scenario Number	Capital Costs (2009$/kW)					Total Cost for 12 GW of Wind (Billion 2009$)
	Wind Farms	Collector & Interconnection	Electric Transmission	Wind Energy Backup	Total (2009$/kW)	
1	2,395 (same for all scenarios)	243 (same for all scenarios)	1,260 (same for all scenarios)	402	4,300	51.6
2				418	4,316	51.8
3 A				207	4,105	49.3
3 B				337	4,235	50.8
3 C				452	4,350	52.2
3 D				582	4,480	53.8
4 A				430	4,328	51.9
4 B				835	4,733	56.8
5 A				473	4,371	52.4
5 B				920	4,818	57.8

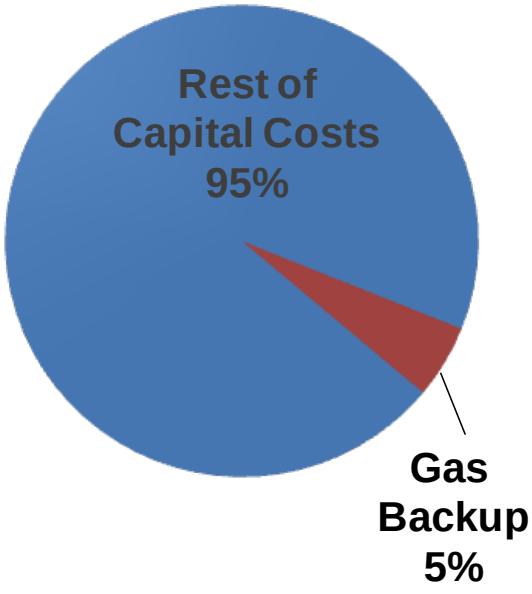
Summary of Wind Backup Capital Costs

- Wind backup capital costs: $207/kW to $920/kW.
- Scenario 3a is lowest cost.
- Scenario 5B is highest cost.
- Scenario 1 is lower-to-middle end of costs.

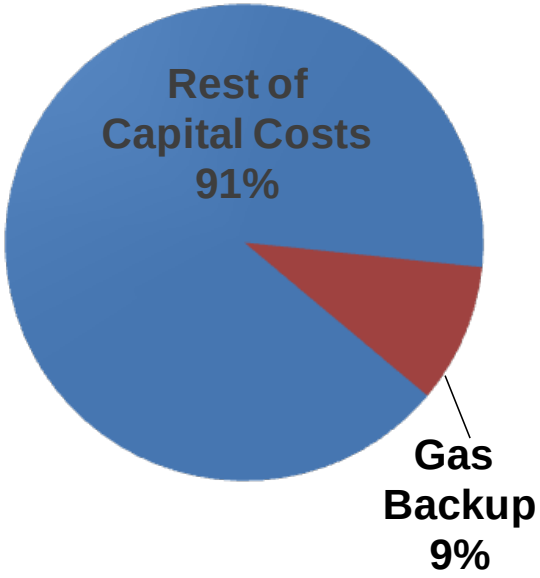


Summary of Capital Costs

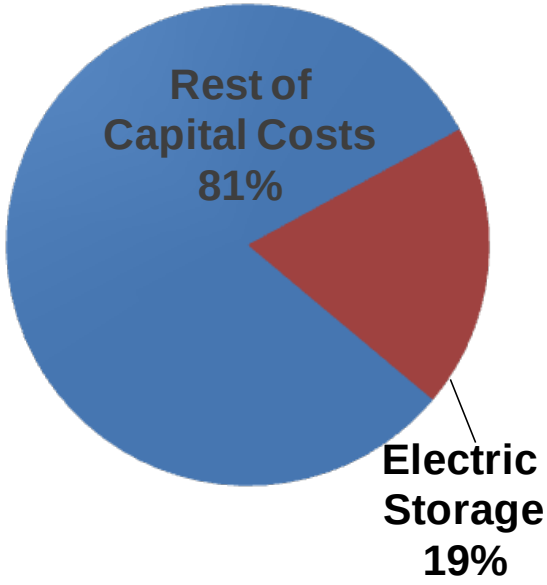
Lowest Cost (#3A)
Use Existing CTs in CA
$4,105/kW



Low-to-Mid-Range Cost (#1)
Build New Gas Backup in WY
$4,300/kW



Highest Cost (#5B)
Build New Electricity Storage in CA
$4,818/kW



Summary of Conclusions from Phase 2

- Total capital costs: $49 billion - $58 billion ($4,100 - $4,800 per kW).
  - Backup capacity is relatively small percentage of total capital costs.
- Natural gas CTs are currently the most cost-effective means of providing backup capacity.
  - The lowest capital cost option is to rely on existing CTs and pipeline capacity to provide backup (if available).
- If new infrastructure is required, it would be less costly to build in Wyoming than in California.
  - Wyoming's abundance of natural gas may also give the state an advantage as a wind energy exporter.

Possible Next Steps

- Foster public-private financing relationships
- Conduct more detailed cost analysis for firming assets
- Track federal policies and inform policy makers
- Examine cost recovery for wind firming options

Thank You

Phase 2 Report Available at: www.icfi.com/collector

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