Wind Integration Workshop
April 6, 2012
Notes:

Objective

The purpose of the Idaho Power wind integration analysis is to answer two questions:

1. How much wind generation can the Idaho Power customers and the Idaho Power electric system accommodate?
2. What are the costs of integrating wind generation into the Idaho Power system?

Procedure used to answer the two questions

Select a test year to identify the customer load and system characteristics (test year = 2017)

Select wind generation quantity (three levels, 800, 1000, and 1200 MW of nameplate generation)

Characterize the wind variability (analysis completed by 3Tier and Energy Exemplar):

> 3Tier projected hourly wind generation and a representative day-ahead forecast of the wind generation. Energy Exemplar used the 3Tier wind projections to create 100 different hourly wind forecasts for the 2017 test year at each wind quantity (800, 1000, and 1200 MW of nameplate generation).
>
> Idaho Power calculated the 90th percentile of the wind forecast error and used the 90th percentile analysis to estimate the dynamic capacity necessary to meet 90 percent of the day-ahead wind forecast errors. At times, there will be insufficient dynamic capacity. When there is insufficient dynamic capacity, including times of low customer load, Idaho Power may be unable to integrate all of the wind and instead Idaho Power will turn to the regional electric markets. It will be necessary to curtail wind at times.

Simulate operation of the Idaho Power system:

- Model the Idaho Power system using the What's Best optimization software
- Model the Idaho Power system using Energy Exemplar's Plexos model
- Model the Idaho Power system under low, median, and high water conditions
- 100 wind forecast scenarios matching the wind forecast error characteristics (day-ahead)

Calculate the net-cost difference under two scenarios (net costs equals total costs minus total sales revenue). The two scenarios:

Scenario 1: Idaho Power is responsible for integrating the wind.

Scenario 2: Idaho Power is not responsible for integrating wind (wind integration is "not our problem", a theoretical case used as a benchmark for comparing costs).

The wind Integration cost is the net-cost difference in the two scenarios divided by the MWh of wind generation (the MWh of wind generation is equal in the two scenarios):

$$Wind\ Integration\ Cost\ = \frac{Scenario\ 1\ Net\ Cost - Scenario\ 2\ Net\ Cost}{Wind\ Generation\ in\ MWh}$$

Idaho Power then used the 100 wind forecast scenarios to simulate the system and study system operations during the events when there was insufficient dynamic capacity, due to the 90th percentile methodology, due to low customer load, or due to other factors, to accommodate the wind variability.

The wind integration cost only includes the costs of holding the dynamic capacity necessary to prepare for wind variability. At times, Idaho Power will not be able to meet the 90th percentile dynamic capacity guideline and the wind integration cost calculations account for the reduced dynamic capacity.

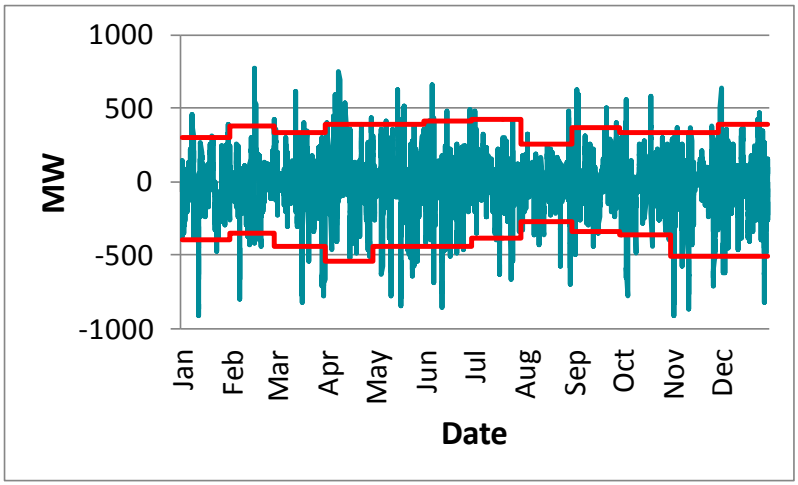
Wind Variability

3Tier, Energy Exemplar, and Idaho Power created hourly wind generation for the 2017 test year at three levels of wind nameplate generation (800 MW, 1000 MW, and 1200 MW). Energy Exemplar developed 100 different hourly wind forecasts for the one wind generation profile (100 forecasts at each wind nameplate generation level, 300 scenarios in total). The wind forecasts are at the day-ahead time horizon meaning twenty-four to forty-eight hours in the future.

Idaho Power calculated the hourly forecast error for each of the 100 scenarios by subtracting the wind hourly profile from each of the 100 forecast scenarios. Idaho Power then used the 90th percentile of the hourly forecast error distribution to determine the monthly dynamic capacity guidelines for wind. Idaho Power recognizes the seasonal variation in wind generation and the dynamic capacity guidelines are different for each calendar month. The 90th percentile procedure is identical to the percentile methods that Idaho Power uses for hydro conditions in resource planning and Idaho Power recognizes the regulatory precedent to use the 90th percentile planning criteria in the wind integration analysis.

The dynamic capacity guidelines are used to schedule the system on an hourly basis to meet 90 percent of the anticipated day-ahead wind forecast errors. There will be times when Idaho Power will be unable to meet the 90th percentile dynamic capacity guideline due to low customer load and other factors. Idaho Power illustrated the dynamic capacity calculations using the following slide:

Wind Variability



The blue line represents the wind forecast error, and the red lines represent the dynamic capacity guidelines. The dynamic capacity guidelines are calculated for each calendar month of the year.

Based on the 90th percentile planning criteria, Idaho Power produced the following slide (Reg Up is dynamic capacity used when actual wind generation is less than expected, Reg Down is the dynamic capacity used when actual wind generation is greater than expected):

Dynamic Capacity Guidelines

Wind Gen	800 MW			1000 MW			1200 MW	
	Reg Up	Reg Down		Reg Up	Reg Down		Reg Up	Reg Down
January	199	-262		246	-325		295	-390
February	252	-246		319	-297		379	-351
March	226	-295		281	-368		339	-444
April	255	-353		331	-450		395	-540
May	258	-290		328	-366		392	-439
June	266	-285		339	-363		409	-436
July	274	-256		355	-322		423	-384
August	172	-179		215	-224		257	-267
September	242	-219		309	-280		371	-337
October	217	-248		275	-308		329	-367
November	226	-336		277	-421		333	-507
December	267	-338		326	-424		394	-510

System Operation

Hydro – Hydro is Idaho Power's wind integration resource of choice because of the quick response as well as the large response capacity. However, the hydro system capacity is insufficient to meet all of the dynamic capacity needs. Using the hydro system for wind integration also means that the hydro system is unavailable for other opportunities. Using the hydro system for wind integration instead of other opportunities creates the "lost opportunities" and the costs of the lost opportunities are a significant part of the wind integration costs.

Coal – Coal is one of the thermal resources that Idaho Power uses to integrate wind generation. Unlike hydro, the fuel for the coal plants is costly. The costs of the fuel as well as the lost opportunities created by using the coal generation to integrate wind make up another part of the wind integration costs. The coal generation does not have the large range and rapid response provided by the hydro resources. At times, Idaho Power may dispatch the coal generation to provide the energy to meet customer load while at the same time spilling water at the hydro facilities to meet the dynamic capacity guidelines necessary to integrate wind.

Natural Gas – Natural gas generation is the other thermal generation resource that Idaho Power uses to integrate wind generation. Like coal, the fuel for the natural gas plants is costly. The costs of the fuel as well as the lost opportunities created by using the natural gas generation to integrate wind make up another part of the wind integration costs. Natural gas does not have as many environmental effects as coal and there will be times when natural gas will be preferred to coal for meeting customer load and preferred for wind integration. The Langley Gulch combined-cycle plant is an efficient thermal resource and under certain load and market conditions, Langley Gulch will likely be the first thermal resource dispatched to meet customer load as well as integrate wind.

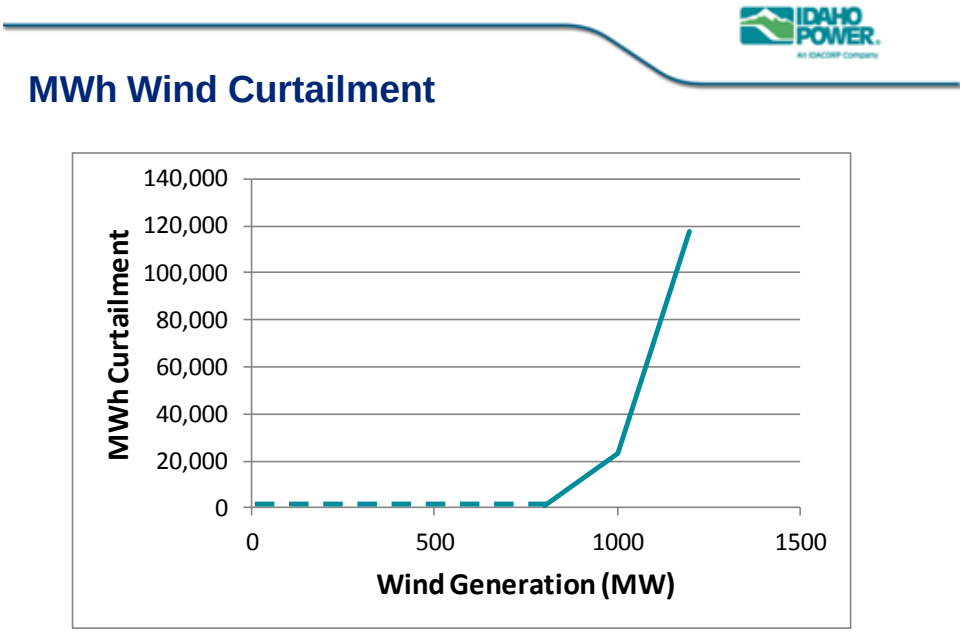
Transmission – Idaho Power has significant transmission connections to the regional electric utilities and the regional energy markets. The purpose of the Idaho Power wind integration study is to determine the quantity of wind that can be integrated into the Idaho Power system, and to determine the cost of integrating that quantity of wind. Idaho Power has based the guideline on being prepared for 90 percent of the wind forecast variation. Using the 90^{th} percentile calculation means that ten percent of the time the wind forecast variation will exceed the dynamic capacity guideline. During the events when 90^{th} percentile dynamic capacity is insufficient, or the times when Idaho Power is unable to provide dynamic capacity at the 90^{th} percentile guideline due to low customer load or other factors, it may be necessary for Idaho Power to use the regional transmission connections and rely on the regional electric utilities and the regional energy markets to accommodate the wind generation connected to the Idaho Power system. Idaho Power anticipates that there will be times when even the regional markets have insufficient dynamic capacity to integrate the wind generation connected to the Idaho Power system. During times when Idaho Power and the regional energy markets have insufficient dynamic capacity to integrate the wind generation connected to the Idaho Power system, Idaho Power may be required to curtail wind, or even curtail customer load, to maintain electrical system stability and integrity.

How Much Wind Generation?

The quantity of wind generation that Idaho Power can integrate at any point in time primarily depends on customer load. System hydro regulations, available storage volume, dispatched resources, FERC Order 890 restrictions, environmental regulations, and numerous other considerations all influence wind integration, but customer load is the main factor affecting wind integration. During times of high load, Idaho Power can integrate more wind than during times of low load. During spring conditions, the quantity of wind that Idaho Power can integrate may be less than 300 MW. During the few peak hours in the summer, the theoretical quantity of wind that can be integrated into the Idaho Power system may be as great as 2400 MW. Building a large quantity of wind generation on the Idaho Power system would not be prudent because the relatively few hours of summer peak customer load means that much of the wind generation would be idle for much of the year because of the electrical system physical restrictions. The Idaho Power Integrated Resource Plans, including the most recent 2011 Integrated Resource Plan, indicate that Idaho Power does not face energy constraints. Idaho Power faces capacity constraints to meet the peak customer load. Wind is considered to be almost a pure energy resource. Wind can be counted on to provide very little, if any, capacity during times of peak customer load in the Idaho Power service territory in southern Idaho.

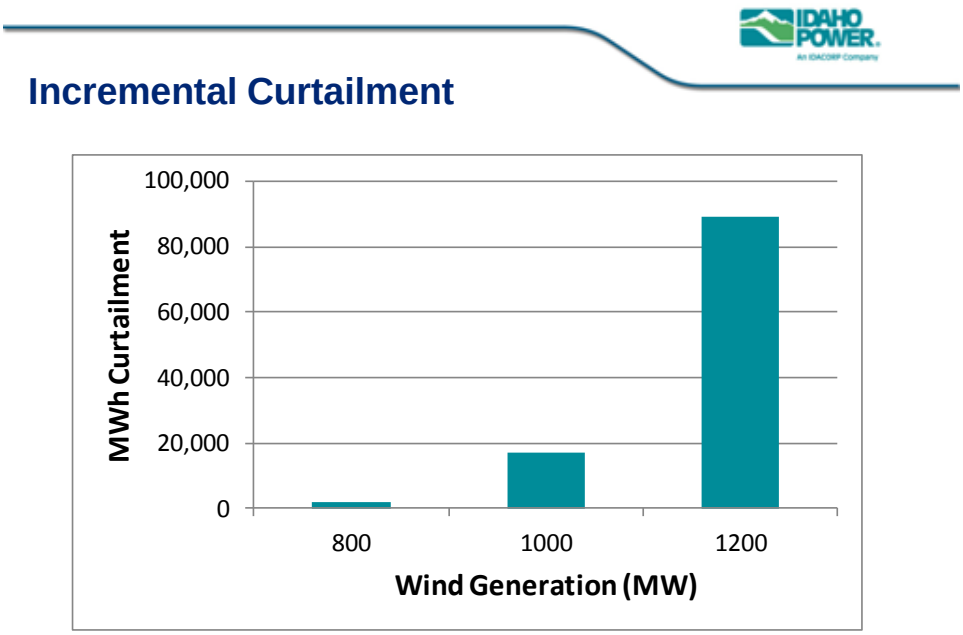
Curtailment

There will be times when wind generation will be curtailed to maintain electrical system stability and integrity. Idaho Power will endeavor to integrate the wind energy into the Idaho Power system or the regional electric grid, however curtailment is real and paying a wind integration charge will not exempt a wind project from curtailment. Curtailment will occur as shown in the following slide:



The slide shows that curtailment occurs at wind generation levels below 800 MW and the curtailment hours increase as the wind generation connected to the Idaho Power system increases (curtailment at generation levels below 800 MW is difficult to see due to the range of the vertical axis). At 800 MW of wind generation, the estimated curtailment is approximately 5,000 MWh of energy. The total curtailment increases to approximately 20,000 MWh at 1000 MW of wind generation, and to over 100,000 MWh of energy when 1200 MW of wind generation is connected to the Idaho Power system.

Idaho Power presented a second slide showing the estimated incremental curtailment:



The incremental curtailment represents the additional curtailed energy that results from connecting addition wind generation to the Idaho Power system. The additional curtailment from connecting another 300 MW to the approximately 500 MW of wind generation presently connected to the Idaho Power system is approximately 2,000 MWh (shown at 800 MW on the chart). The incremental curtailment increases to over 17,000 MWh at 1000 MW of wind generation, and to nearly 90,000 MWh when there is 1200 MW of wind generation connected to the Idaho Power system. As mentioned earlier, the chart represents times when wind generation will be curtailed to maintain electrical system stability and integrity and paying an integration charge does not exempt a project from curtailment.

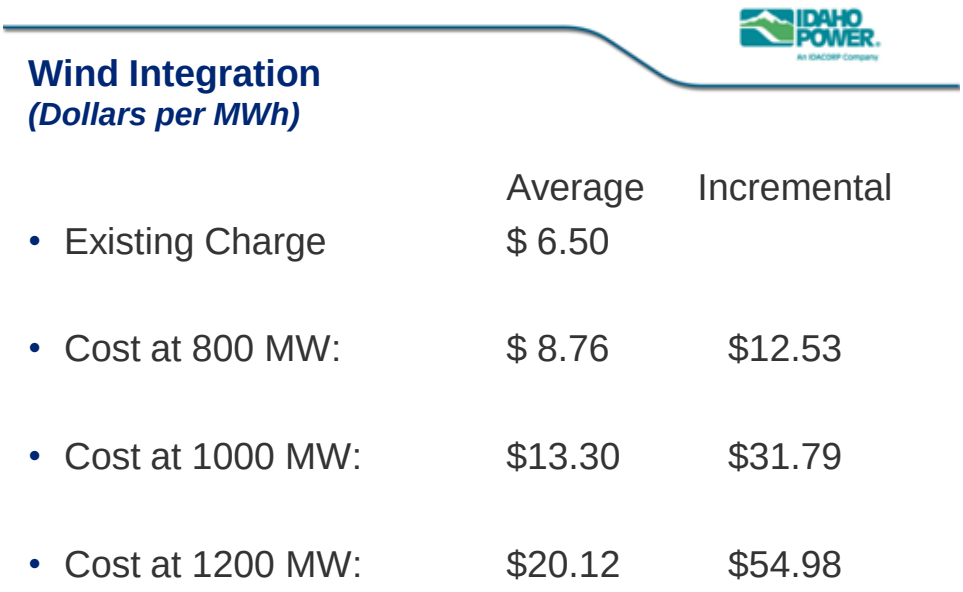
Idaho Power envisions a number of possible curtailment plans including:

- First in Time, First in Right – Senior contracts are the last to be curtailed
- Equal Sharing – The output from all wind projects is reduced by the same proportion

Idaho Power requires that any curtailment procedure be practical, automatic, and capable of full dispatch within ten minutes.

Integration Costs

Wind integration costs depend on the quantity of wind generation connected to the Idaho Power system. Idaho Power analysis indicates that the wind integration costs increase dramatically after approximately 800 MW of wind generation is connected to the Idaho Power system:



The cost values presented in the slide are from the following table (table repeated on the following page):

Wind Generation Capacity (MW)	Total Wind Energy Produced (MWh)	Integration Cost	Average Integration Cost per MWh	Incremental MWh	Incremental Integration Cost	Incremental Integration Cost per MWh
500	1,195,010	$ 7,767,563	$6.50			
800	1,912,016	$ 16,749,894	$8.76	717,006	$ 8,982,331	$12.53
1000	2,381,517	$ 31,677,547	$13.30	469,501	$ 14,927,652	$31.79
1200	2,847,159	$ 57,280,344	$20.12	465,643	$ 25,602,797	$54.98

Both average and incremental costs are based on the 2017 test year analysis. The average cost is calculated by dividing the total annual wind integration cost by the total annual MWh of wind energy. For example, the average cost of $13.30 represents the cost per MWh if the energy produced from all 1000 MW of wind generation connected to the Idaho Power system is assessed the wind integration costs. The $13.30 represents the total annual integration cost divided by total annual MWh of energy produced from all 1000 MW of wind generation ($31,677,547 divided by 2,381,517 MWh).

The incremental cost show the additional cost imposed by the additional wind generation. The calculation represents the cost when the 200 MW of wind generation from 800 MW to 1000 MW is responsible for the additional costs imposed by increasing wind generation from 800 MW to 1000 MW. The incremental cost of increasing wind generation from 800 to 1000 MW is $14,927,652 and $14,927,652 divided by the incremental wind energy of 469,501 MWh yields an incremental cost of $31.79 per MWh. The incremental cost of the 200 MW of wind generation from 1000 MW to 1200 MW is determined using the same calculation methods ($25,602,797 divided by 465,643 MWh equals $54.98 per MWh).

The incremental cost calculated at 800 MW is based on the amount of wind presently connected to the Idaho Power system as well as the regulatory framework establishing the existing wind integration charge. Presently, there is approximately 500 MW of wind generation connected to the Idaho Power system. Idaho PUC Order 30488 identified the boundary between Tier 2 and Tier 3 wind integration costs at 500 MW of wind generation connected to the Idaho Power system. The incremental cost calculated at 800 MW of wind generation assumes that the first 500 MW of wind generation connected to the Idaho Power system will be assessed the $6.50 per MWh integration charge identified in Idaho PUC Order 30488. The incremental cost at 800 MW is calculated when an additional 300 MW of wind generation increases the nameplate capacity of wind generation connected to the Idaho Power system from 500 MW to 800 MW (incremental costs of $8,982,331 divided by the incremental energy of 717,006 MWh yields an incremental integration cost of $12.53 per MWh).

Summary:

Wind integration is a genuine concern. Idaho Power has worked with international consultants 3Tier and Energy Exemplar and others in the utility industry to prepare this study of wind integration and the costs of wind integration. Idaho Power welcomes your questions, comments, and suggestions. We encourage you to deliver your comments to Idaho Power by the end of business on April 20, 2012 so that we can incorporate your thoughts and suggestions in our analysis:

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