Strategic Midwest Area Renewable Transmission (SMARTransmission) Study

QUANTA TECHNOLOGY

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Stakeholder Meeting & Web Conference

Sept 21, 2010

Agenda

- Introduction – Steven T. Naumann - VP Wholesale Market Development
- Phase 1 Summary
- Phase 2 Overview
  - Modeling Assumptions
  - Results Discussion
- Conclusions Phase 1 & 2
- Q&A

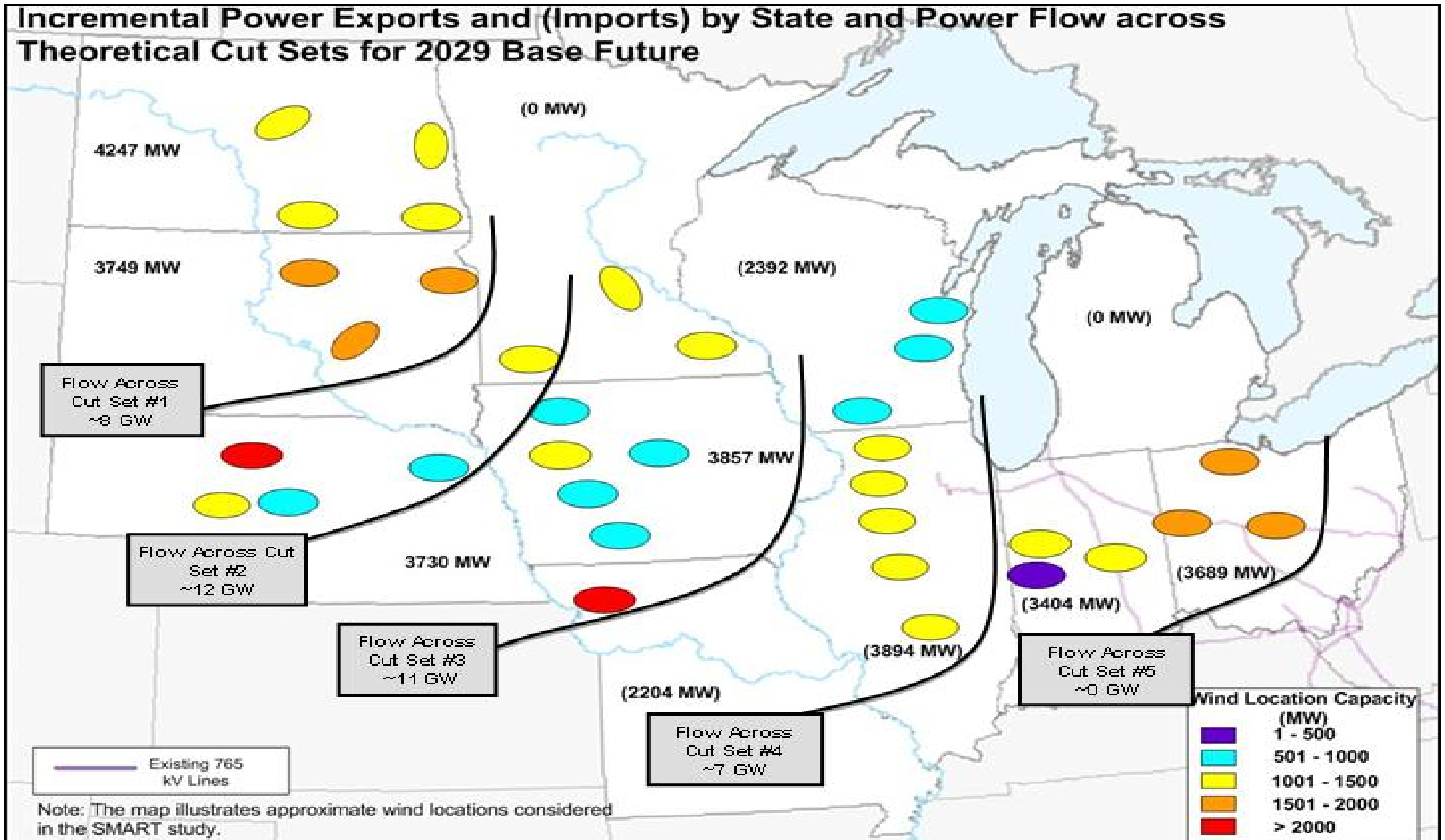
Summary of State Renewable Portfolio Standards

State	Summary of RPS Requirements	SMARTransmission RPS Assumptions for 2029
Iowa	2% 2011 or 105 MW	20%
Illinois	25% by 2025	25%
Indiana	None	20%
Michigan	10% 2015	20%
Minnesota[1]	25% by 2025	27.5%
Missouri	15% 2021	20%
North Dakota	10% 2015	20%
Nebraska	None	20%
Ohio	25% by 2025	25%
South Dakota	10% 2015	20%
Wisconsin	10% 2013 20% 2020 25% 2025	25%

[1] Xcel Energy has a 30% RPS requirement and the rest of the state has a 25% RPS requirement. Because Xcel Energy is approximately half the load in the state, the RPS in Minnesota was assumed to be 27.5% for the entire state

Phase 1 Summary

- Initially developed eight proposed alternatives
  - 1 - All 345kV
  - 2 – Combination 345kV and 765kV
  - 5 – 765kV



Phase 1 Summary (Con't)

- Developed on-peak & off-peak cases for the following futures
  - Base Wind
  - High Gas
  - Low Carbon
- Five Sensitivities
  - High Wind, Low Wind
  - High Load, Low Load
  - Imports SPP
- Based on performance and cost, reduced the number of alternatives from eight to five to three
  - Combination 345kV and 765kV – Alternative 2
  - 765kV – Alternative 5
  - 765kV with long HVDC – Alternative 5A

Phase 1 - Summary of Costs

Element	$M
Transmission Lines (includes right-of-way costs)	
Single circuit 345 kV (USD / mile)	1.50
Double circuit 345 kV (USD / mile)	1.97
Single circuit 765 kV (USD / mile)	2.71
Transformers	
345/230 kV, 500 MVA (USD / unit)	6.5
765/345 kV, 1000 MVA (USD / unit)	12.0
765/345 kV, 2250 MVA (USD / unit)	21.0
Network Stations (does not include land costs)	
345 kV (USD / station)	11.8
765 kV (USD / station)	25.1
Major River Crossings	7.0
HVDC Undersea Cable (USD / mile)	9.0
HVDC Overhead HVDC (USD /mile)	5.0
Reactive Correction	
Shunt reactors (USD / MVAr)	0.0420

Line Costs in Millions of Dollars	Alt 2	Alt 5	Alt 5A
Estimated Cost for 345 kV Lines	$9,053	$158	$158
Estimated Cost for 765 kV Lines	$10,705	$21,066	$19,149
Total Cost Transmission Lines	$19,758	$21,224	$19,307
Transformers Costs			
Estimated Cost of 765/345 kV Transformers	$445	$848	$848
Estimated Cost of 230/345 kV Transformers	$7	$7	$7
Total Costs Transformation	$452	$855	$855
Network Substation/Station Costs 345 kV	$472	$59	$59
Network Substation/Station Costs 765 kV	$552	$879	$853
Total cost	$1,024	$938	$912
River Crossing line costs	$35	$56	$56
Costs	$1,427	$1,281	$2,500
Shunt Reactors	$1,115	$1,413	$1,205
Total Estimated Costs	$23,811	$25,767	$24,835

2029 Revised Conceptual Alternative 2- 345 kV and 765 kV

Note: Actual line routing to be determined later as part of detailed studies including siting and permitting process.

2029 Revised Conceptual Alternative 5 - 765 kV

Note: Actual line routing to be determined later as part of detailed studies including siting and permitting process.

2029 Revised Conceptual Alternative 5 - 765 kV and HVDC

Note: Actual line routing to be determined later as part of detailed studies including siting and permitting process.

Results of Phase 1

- Eight alternatives were evaluated: one 345kV only; two 345kV/765kV; and five 765 kV alternatives.
- After evaluating all the alternatives from a cost and performance perspective, modified versions of Alternative 2 (345 kV/765 kV), Alternative 5 (765 kV), and Alternative 5A (765 kV with HVDC) were chosen for additional analysis using futures and sensitivities. They were chosen based on their cost and reliability performance in the base case which contained a total of 56.8 GW of nameplate wind generation within the study area. This amount of wind generally reflects the current RPS requirements for those states that have an RPS requirement or goal.
  - The 345 kV alternative solves for the low wind case only and the cost of that alternative is higher than the other alternatives so it was not analyzed further.

Results of Phase 1 (cont.)

- Alternatives 2, 5, and 5a all work technically in the futures and sensitivity analysis with manageable contingencies and mitigations. Because HVDC options may not provide local benefits by offering low cost on and off ramps for energy in southern Iowa, northeastern Missouri, and Illinois Alternatives 2 and 5 were chosen for "sequencing" – developing and testing interim-year plans toward the ultimate 2029 build out.
  - Based on the Study's assumptions, the SMART Study team developed workable solutions for 2019 and 2024 for Alternatives 2 and 5. This effort provides a potential scenario for a phased build out. Actual sequencing of the transmission overlay will be dependent on where and when wind generation is developed as well as the magnitude and distribution of load growth.

Phase 2 Overview

- Two alternatives selected for economic evaluation
  - Alternative 2 (Combined 345kV and 765kV)
  - Alternative 5 (765kV only)
- Security Constrained Unit Commitment and Dispatch simulations for 2029
- Generation Futures
  - High Gas
  - Low Carbon
  - Low Wind

Key Assumptions (System)

- RGOS used as base model
- Excluded future RGOS wind resources
- Added SMART future wind resources through 2029
- No incremental wind generation for Michigan
- Demand annual growth rate
  - Mostly at 1.4%
  - Some at 1.0%
  - Zero for outside footprint and Michigan (2019 level)
- Ensured adequate reserve margin
  - More future generation resources for MISO, PJM, MAPP

Key Assumptions (Con't)

Uncertainty		Unit	RGOS Study Value	SMART Study Value
Demand and Energy	Demand Growth Rate	%	1.60	Varying[1]
	Energy Growth Rate	%	2.19	Varying[1]
Fuel Prices (Starting Values)	Gas	($/MBtu)	6.22[2]	Same[3]
	Oil	($/Mbtu)	PowerBase Default	Same[3]
	Coal	($/Mbtu)	PowerBase Default (by unit)	Same[3]
	Uranium	($/Mbtu)	1.12	Same[3]
Fuel Prices (Escalation Rates)	Gas	%	2.91	Same[3]
	Oil	%	2.91	Same[3]
	Coal	%	2.91	Same[3]
	Uranium	%	2.91	Same[3]
Emission Costs	SO_2	($/ton)	PowerBase Default[4,6]	Same[3]
	NOx	($/ton)	PowerBase Default[5,6]	Same[3]
	CO_2	($/ton)	0[7]	Same[3]
	HG	($/ton)	60000000.0	0
O&M for New Wind	Variable O&M	($/MWh)	5.46[8]	Same[3]
Wind Profile	Hourly Wind Profile		As collected by NREL for new wind power development in 2004-2006	Same[3]

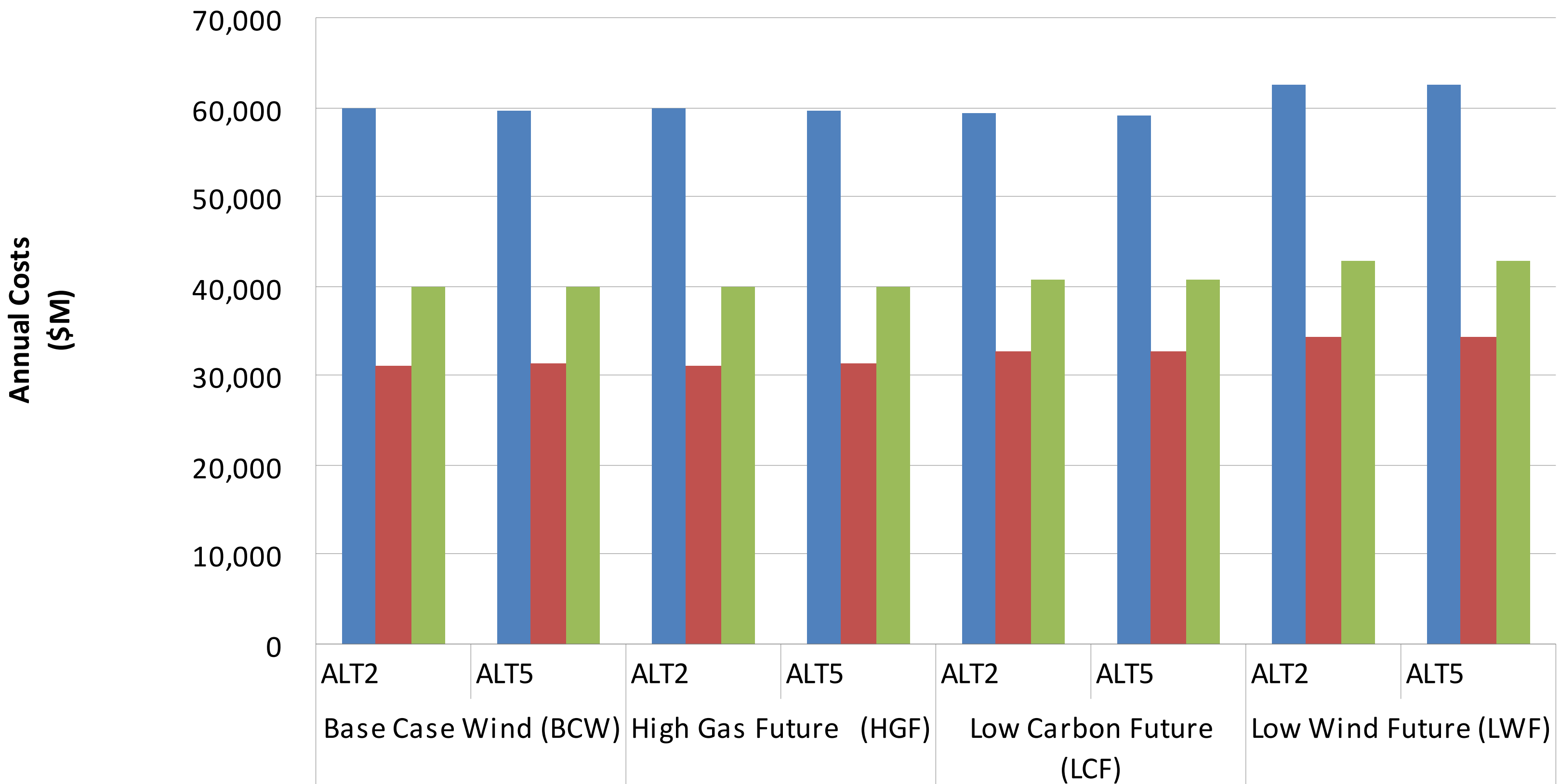
1. Demand growth rate and energy growth rate used in the Phase 2 production cost model are listed in Table B-1 in Appendix B.
2. Henry Hub 2010 gas price forecast.
3. The same as the MISO RGOS model.
4. Ventyx SO_2 annual and seasonal allowance price forecast: $525.72 in 2019, $466.22 in 2024, $274.80 in 2029.
5. Ventyx NO_X annual allowance price forecast: $564.66 in 2019, $574.37 in 2024, $626.94 in 2029. NO_X seasonal allowance price is modeled as zero in this study.
6. Ventyx uses a proprietary emission price forecast model (EFM) to simulate emission control decisions and results simultaneously in the three cap-and-trade markets (SO_2 , NO_X Annual, and NO_X Seasonal).
7. Non-zero carbon tax values will be used in the carbon tax sensitivity studies.
8. MISO confirmed that the variable O&M value used in the RGOS study for the new wind farms came from the Eastern Wind Integration and Transmission Study (EWITS).

Economic Evaluation Metrics

- Adjusted Production Cost (APC)
  - = Production Cost + Emergency cost + Purchase Cost – Sales Revenue
    - Production Cost = Fuel cost + Environmental Cost + Var O&M Cost
    - Emergency Cost = Emergency MWH * $2000/MWh
    - Cost of Purchases = MW Import x Zonal Load Weighted LMP
    - Revenue from Sales = MW Export x Zonal Generation Weighted LMP
- Load Cost (or load payment)
  - = Zonal Load Weighted LMP x Zonal Load MWH
- 70/30 Metric
  - = 70% * Annual APC + 30% * Annual Load Cost
  - Referred to as MISO RECB II metric.
- Emission Release and Cost
  - = Release (KTons) and cost ($M) of CO_2, SO_2, and NO_X

Results (Base Case Wind)

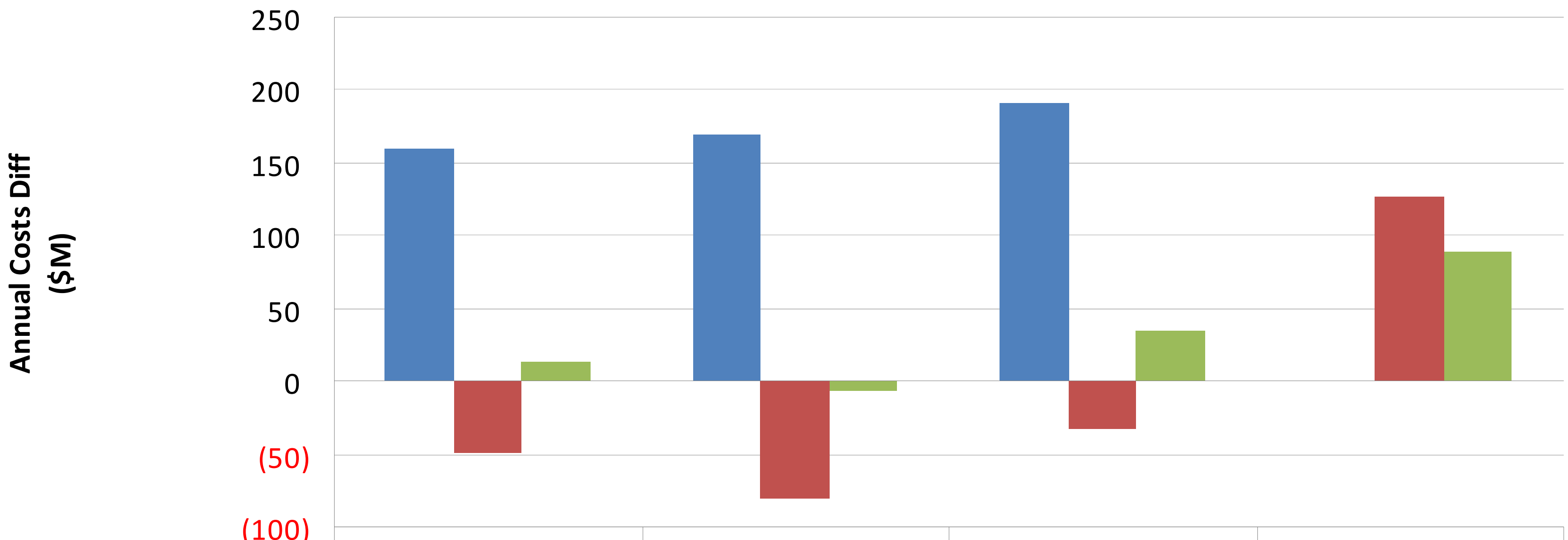
- Annual Cost Metrics Comparison



	Base Case Wind (BCW) ALT2	Base Case Wind (BCW) ALT5	High Gas Future (HGF) ALT2	High Gas Future (HGF) ALT5	Low Carbon Future (LCF) ALT2	Low Carbon Future (LCF) ALT5	Low Wind Future (LWF) ALT2	Low Wind Future (LWF) ALT5
Load Cost ($M)	59,907	59,748	59,819	59,649	59,343	59,152	62,416	62,416
APC ($M)	31,255	31,304	31,219	31,300	32,735	32,767	34,435	34,309
70/30 Metric ($M)	39,851	39,837	39,799	39,805	40,717	40,683	42,829	42,741

Results (Base Wind Case – cont'd)

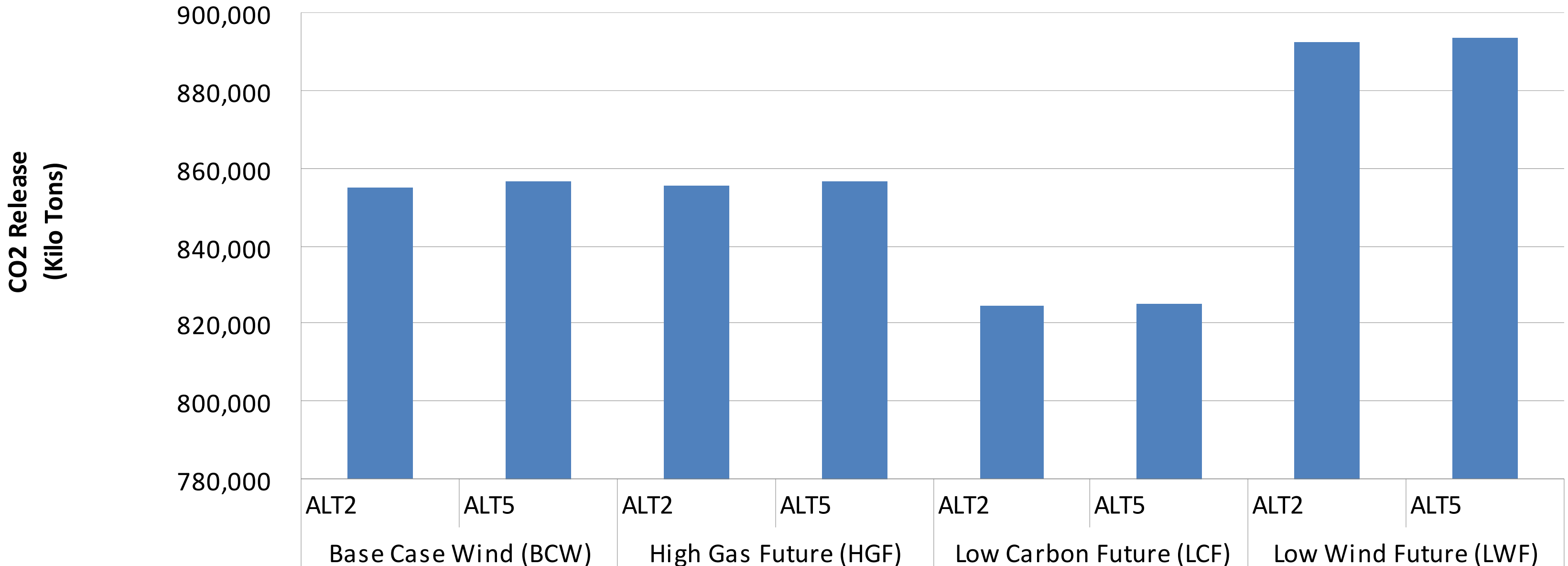
- Cost Metrics Deltas – All less than 1%



	ALT2-ALT5 Base Case Wind (BCW)	ALT2-ALT5 High Gas Future (HGF)	ALT2-ALT5 Low Carbon Future (LCF)	ALT2-ALT5 Low Wind Future (LWF)
ΔLoad Cost ($M)	159	170	191	~ 0
ΔAPC ($M)	(49)	(81)	(32)	126
Δ70/30 Metric ($M)	13	(6)	35	88

Results (Base Wind Case – cont'd)

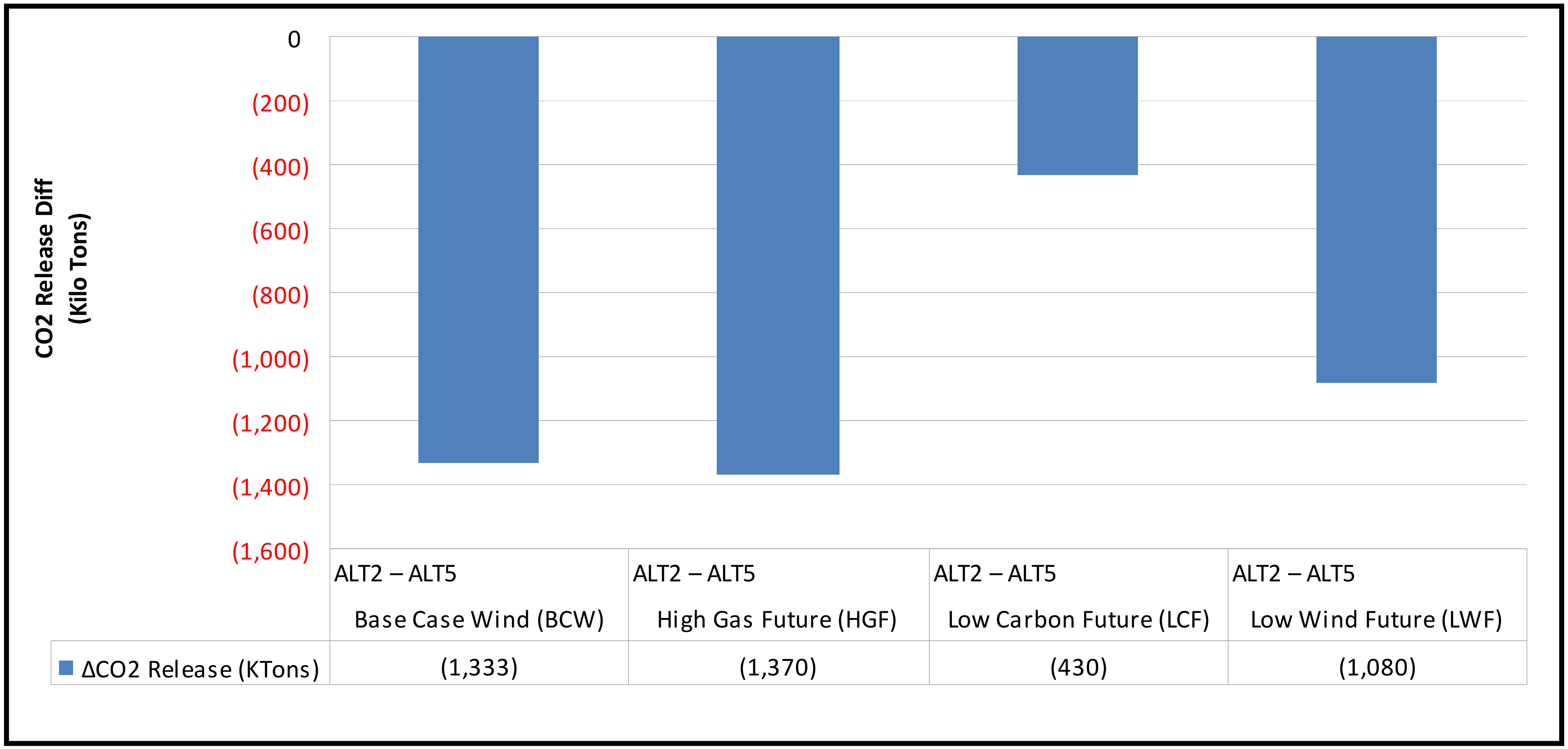
- CO_2 Emission Release Comparison



	Base Case Wind (BCW)		High Gas Future (HGF)		Low Carbon Future (LCF)		Low Wind Future (LWF)	
	ALT2	ALT5	ALT2	ALT5	ALT2	ALT5	ALT2	ALT5
CO2 Release (KTons)	855,130	856,463	855,223	856,593	824,672	825,102	892,517	893,597

Results (Base Wind Case – cont'd)

- ΔCO_2 Emission Release Delta – All less than 1%



Results and Observations

Base Case Wind (BCW)	Alt 2	Alt 5	Difference	% Difference
Load Costs ($M)	59,907	59,748	159	0.3%
APC ($M)	31,255	31,304	(49)	0.2%
70 / 30 Metric ($M)	39,851	39,837	13	< 0.1%
CO_2 Release (kTons)	855,130	856,463	(1,333)	0.2%
SO_2 Release (kTons)	2,078	2,077	1	< 0.1%
NO_x (kTons)	984	984	0	0.0%

- Equal/Comparable Economic Performance
- Equal capability to deliver wind generation
- Equal/Comparable emission release and cost

Conclusions Phase 1 & 2

Three EHV alternatives were recommended for study area

- 345 kV and 765 kV
- 765 kV
- 765 kV with HVDC

- Alternatives are comparable
  - Reliability
  - Economic (Market Simulations)
  - Environmental impact

QUESTIONS?

Questions/Comments - info@smartstudy.biz

Postings - www.smartstudy.biz