Real Options for Real Communities: Incorporating Uncertainty into Small-Scale Energy Planning

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“Real Options in Energy Economics”

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Bowling Green, Ohio Wind Farm

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Content

- Project Description
- Sources of Project Uncertainty & Opportunities for Flexibility
- Example of a Simple Expansion Option for Community Wind
- Survey: Accessibility of Real Options Analysis
- Windustry Tool for Community Wind Planning: Augmentation with Real Options
- Conclusions & Future Work

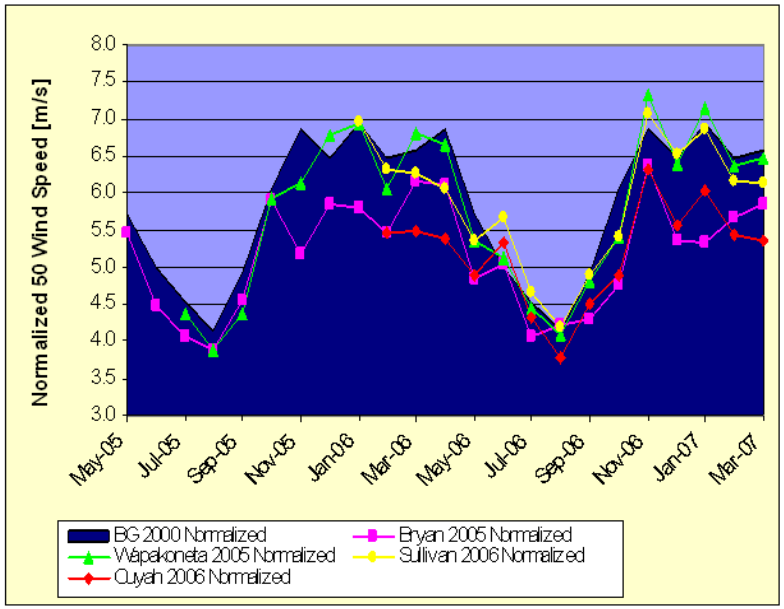
Project Description: Small-scale energy planning

- Utilities historically dominated US energy planning with long-term contracted, large-scale, & fossil-fuel based electricity generation facilities
- PURPA 1978 opens up regulatory framework to promote Independent Power Producers
  - Forces utilities to buy power at “avoided-cost” rate
- Oil crisis prompts demonstration projects for grid-tied wind applications by the DOE in mid-1970’s
- Wind development in the US prevalent in California in the 1980’s, stagnant through late-1990’s and has picked up considerably in last 2 years (doubling cumulative capacity from 2006 to 2008)

Project Description: Community Wind Farms

- Community Wind, a tradition in Europe, is a small but important piece of American Growth
- While resistance to wind projects can be strong, community wind projects are initiated and supported locally
- Community Wind in Ohio:
  - Precedent: 2003 Bowling Green project of 4 1.8 MW turbines (largest turbines west of the Rockies at the time)
  - Recent passage of Ohio RPS and ODOD renewable energy grants make wind projects attractive
  - Communities in “rust-belt” looking for job creation opportunities
  - Municipal utilities have a lot of autonomy

Project Description: Wind for Wapakoneta



Annual Wind Speed averages of various Ohio Test Sites, Wapakoneta outperforms all other sites even when normalized to historical trends

- Model community: Wapakoneta
  - Two Year DOE Tall Tower Wind Assessment Study shows that wind speeds at Wapakoneta, Ohio are high class 2 to low class 3
  - Wapakoneta is a municipal utility
  - In addition, the city owns a large body of land near the test site and a major interstate that would promote ease of installation
  - Finally, there is community interest from Wapakoneta officials and local businesses for such a project

Project Description: Wind in Wapakoneta

- What are the next steps?
  - Following on the wind assessment study, other information is necessary prior to going ahead with such a large-investment project for the city
  - Key to this is an economic feasibility study that incorporates:
    - project costs
    - offsets in electricity costs to the community
    - Regulatory incentives
  - All of the above involve a large amount of uncertainty
  - Any thorough economic feasibility study will accurately address these uncertainties as well as include the value of various possibilities for project flexibility

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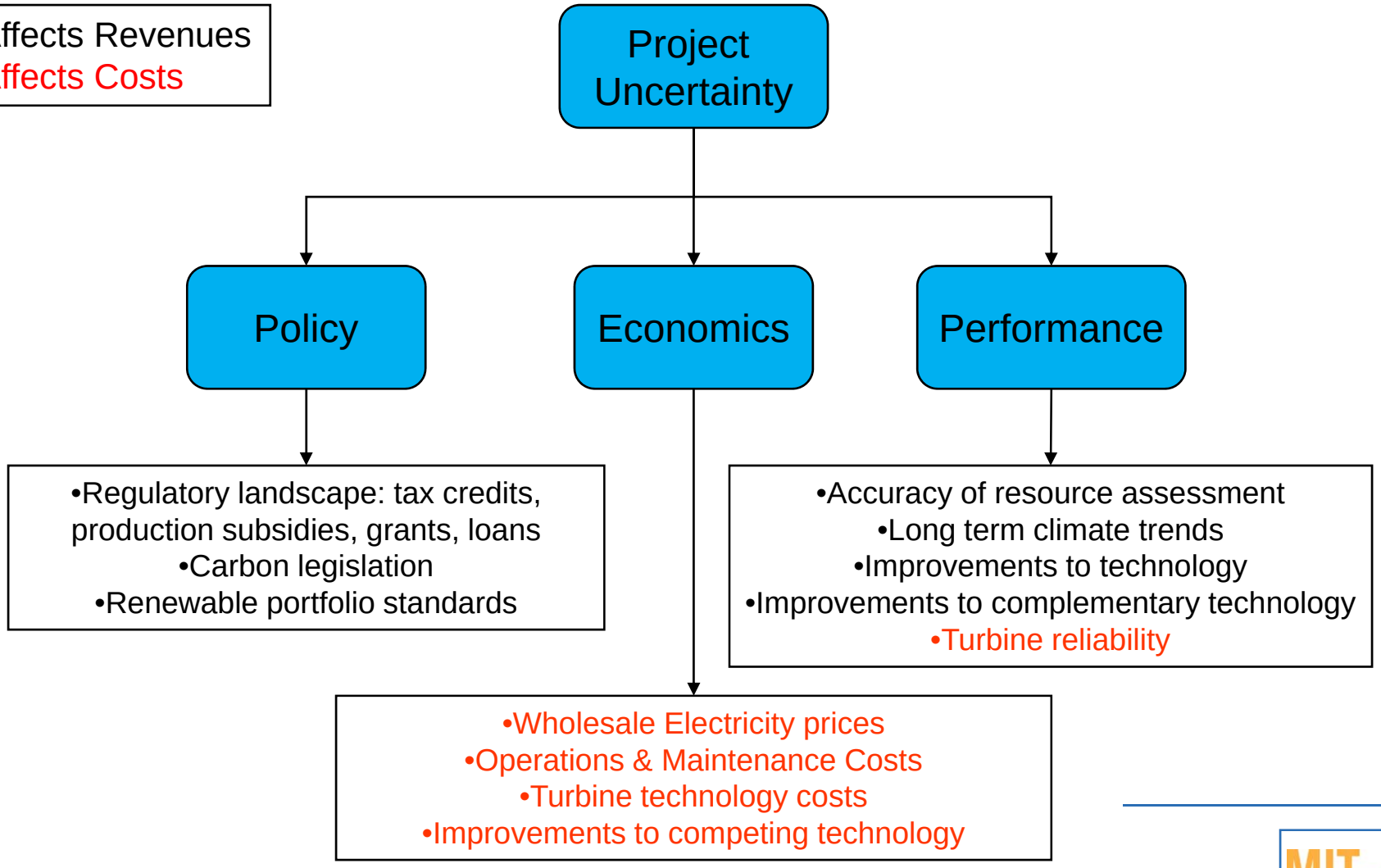
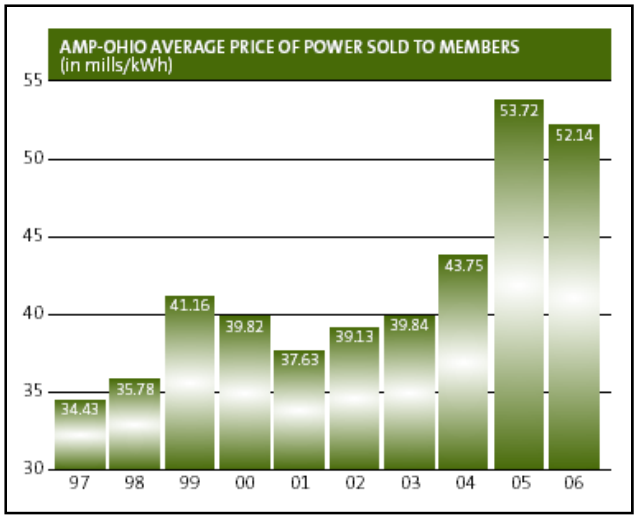
Sources of Project Uncertainty

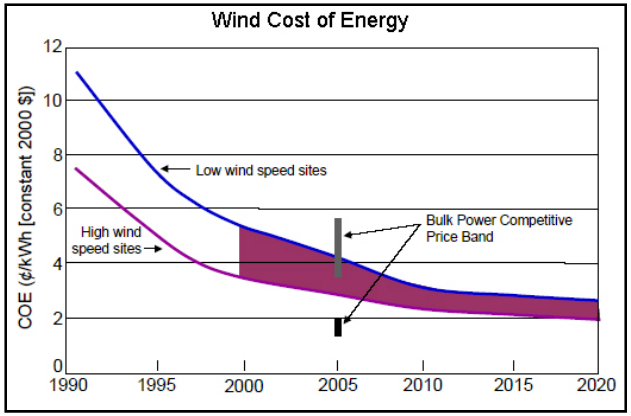
- Affects Revenues
- Affects Costs



Sources of Project Uncertainty: examples

- Wholesale electricity price
  - Wholesale electricity sold to Wapakoneta sub-stations from AMP-Ohio; trend in electricity prices for past several years shown below[1]
- Regulatory Incentives, currently available and subject to change year to year[2]:
  - State Grants up to $150,000 for a large commercial wind project
  - Capped production incentives of $0.01/kWh
  - $0.019/kWh production tax-credit at federal levels
- Installation and Maintenance Costs
  - Project Costs for Wind have been falling steadily as shown below[3]:





[1] http://www.amp-ohio.org/pdf/AMP_Ohio_2006_Annual_Report.pdf
[2] http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=OH&RE=1&EE=1
[3] http://www.eere.energy.gov/windandhydro/windpoweringamerica/ne_economics.asp

Opportunities for Flexibility

- Call Options:
  - Deferral of entire project
  - Expansion from small (< 5 MW) demonstration project to large-scale wind farm
  - Technology upgrade: installation of smaller (~ 1 MW) turbines with planning for eventual replacement by larger (2-3 MW) turbines
- Put Options:
  - Sell-off project to a larger utility
  - Shutdown and sell off equipment
- Compound Options:
  - Deferral, Expansion or Ugrade with Sell-Off or Shutdown

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Example of a Simple Expansion Option for Community Wind

- Dominant source of uncertainty of the three highlighted sources of technology cost, electricity prices and regulation:
  - Wholesale electricity price
    - Largely due to fossil fuel price volatility, especially natural gas
    - Also potential for volatility from demand-supply growth differential
  - Regulation
    - Production-tax-credit a perennial source of uncertainty in US
    - In the future, potential for regulation on CO2 emissions could also cause significant increase in electricity prices
- Options for Wapakoneta community wind project:
  - Call option to expand (starting with small scalable demonstration project)

Real Option Analysis: Expansion

- Use a 2-stage decision tree analysis with Monte Carlo simulations to assess the option of expanding a small (3 MW) wind farm to a larger (20 MW) wind farm; includes option to expand at specified time
- Option value created due to uncertainty in electricity prices and carbon-legislation
  - Wholesale electricity prices projected using Geometric Brownian Motion model with drift 5.07% and volatility 9.31%
  - Carbon prices based on MIT EPPA model for carbon prices based on different hypothetical cap-and-trade programs that have been proposed in the US[5]
  - Small farm higher cost per MW (certain fixed costs incurred regardless of project size)

[5] *Paltsev, S. et. al. "Assessment of US Cap and Trade Proposals," MIT Joint Program on the Science and Policy of Global Change, Report No. 146, April 2007.*

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Real Option Analysis: Expansion

- Hypothetical Costs for a wind farm at Wapkoneta, assumptions:
  - using test site wind profile
  - Ignores regulatory incentives such as PTC or grants
  - uses cost estimates as provided by AWEA and Windustry[6]

Plan1: large upfront investment for large-scale wind turbine farm		
Turbine #	26	
Size Turbine	750	kW
Total MW	19.5	MW
Yearly kWh production / turbine	1,408,464.65	kWHr
Total Cost	$ 20,000,000.00	
Economies of Scale?	yes	
Maintenance Costs / MW	$ 63,000.00	$/MW
Total Maintenance Costs	$ 1,638,000.00	
Carbon offset	19,500.00	tons CO2-e

Model characteristics for the large 20 MW wind farm project plan

Plan2: small upfront investment for small-scale wind turbine farm (scalable)		
Turbine # / installation	4	
Size turbine	750	kW
Total MW	3	MW
Yearly kWh production / turbine	1,408,464.65	kWHr
Total Cost	$ 5,700,000.00	
Economies of Scale?	no	
Maintenance Costs / MW	$ 63,000.00	$/MW
Total Maintenance Costs	$ 252,000.00	
Carbon offset	3,000.00	tons CO2-e

Model characteristics for the small 3 MW wind farm project plan

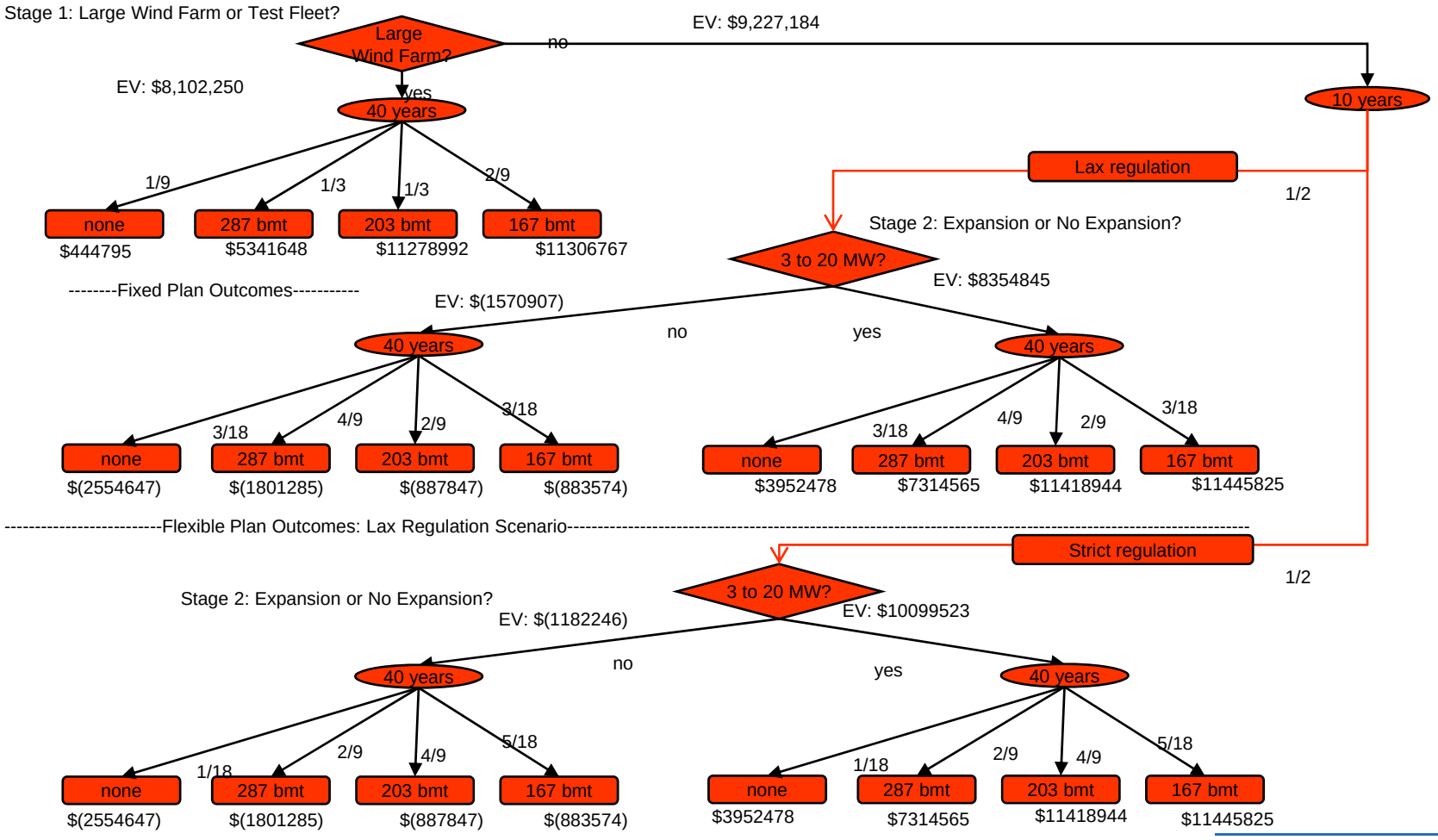
Project Cost Information:

[6] http://www.awea.org/pubs/factsheets/10stwf_fs.PDF

http://www.windustry.org/your-wind-project/community-wind/community-wind-toolbox/chapter-3-project-planning-and-management#wi

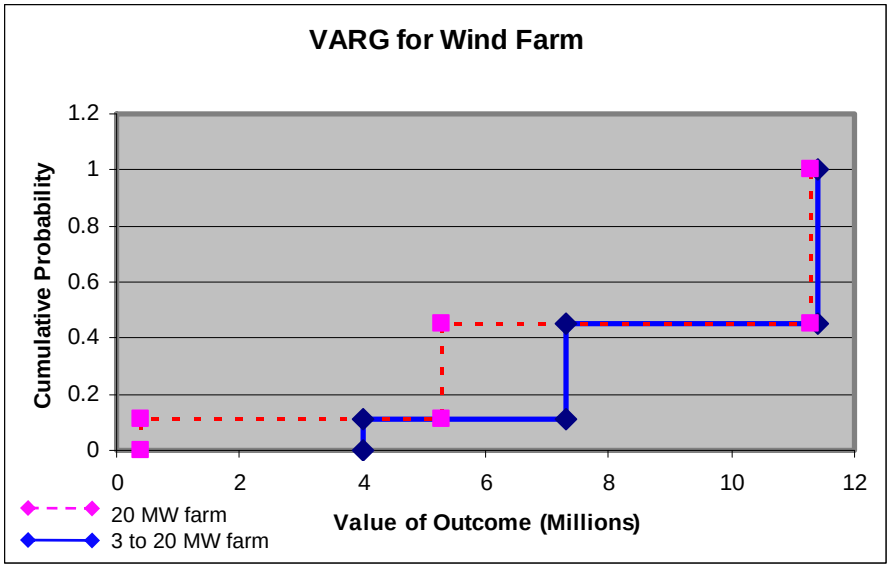
Rached T., Communicating Complexity and Informing Decision Makers, MS Thesis, Engineering Systems Division, MIT, June 2008.

Real Option Analysis: Expansion



Real Option Analysis: Expansion

- Estimated value of option to expand from above set of simulations is ~$1,000,000
- In typical spirit of real options, flexibility in expansion of the wind farm allows for capturing up-side potential of strict carbon legislation and high electricity prices but avoids cost if those scenarios do not occur



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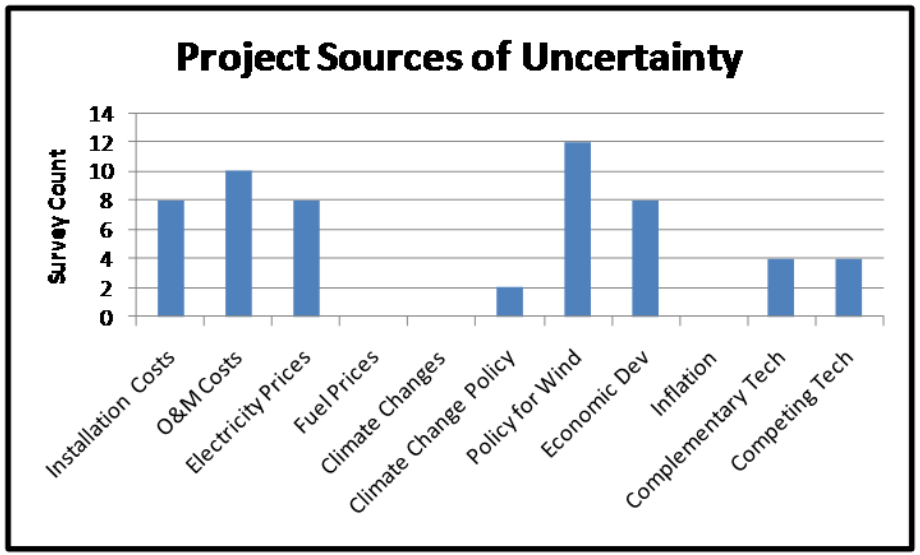
Survey: Accessibility of Real Options

- Real Options can influence assessment of project value for community wind farms
- Survey was conducted to gauge familiarity with real options tools and potential for valuation of community wind projects
- Community Wind a small portion of overall wind development companies
- Survey was sent to 22 known the Community Wind project managers and financial planners within companies who focus specifically on wind and renewable energy development for community projects

Survey: Accessibility of Real Options (Results)

- Results of Survey (16 respondents)
  - 100% of respondents were unfamiliar with the concept of real options
  - 100% of respondents felt that there were significant sources of uncertainty that would affect the financial viability of their projects
    - 12 of the 16 believed that uncertainty in policy for renewable energy could undermine a project's financial performance
    - Other significant sources considered were O&M Costs, Electricity Prices, Installation Costs and Economic Development



Survey: Accessibility of Real Options (Results)

- More on uncertainty:
  - Most (13 of 16) respondents felt that they had “somewhat” addressed the sources of uncertainty in their projects;
  - Specifically, respondents targeted uncertainties from O&M costs (7) and policy change (6)
    - Typically, organizations worked with groups at state and federal levels to advocate / lobby for favorable policy for renewable energy
    - With respect to O&M, contracts were designed to try and tighten margin of uncertainty upfront
    - Other factors that played a role was selection of technology (i.e. choosing 1 MW over larger turbine sizes) and spreading installation costs over a large group of investors (i.e. the Minnesota “flip-it” model)
    - Uncertainty in electricity prices not addressed by any respondent, options not utilized for addressing any uncertainty source

Survey: Accessibility of Real Options (Results)

- Consideration for flexibility in project planning:
  - 12 of 16 respondents had considered flexibility for their projects:
    - 9 considered project expansion
    - 2 considered shutting-down an unprofitable project
    - 1 considered project siting and construction
    - 1 respondent referred to their continual analysis of technology, resources and financing changes as a method of incorporating flexibility into project development
  - Overall, no respondents had used real options either for valuing or planning for flexibility in their projects
  - Given the value that flexibility can provide for community wind projects (as demonstrated in the earlier example), worthwhile exploring how to educate community wind project developers about real options

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Windustry Tool for Community Wind Planning: Augmentation with Real Options

- Windustry is a non-profit based out of Minnesota, USA that has focused on facilitating community wind development for over a decade
- A hallmark accomplishment of the organization has been the creation of a guide for community wind project development including a “wind project calculator” economic feasibility assessment tool[7]
- Presents an opportunity for encouraging use of real options analysis for community wind projects

[7]http://www.windustry.org/your-wind-project/community-wind/community-wind-toolbox/chapter-3-project-planning-and-management/co

Windustry Tool for Community Wind Planning: Augmentation with Real Options

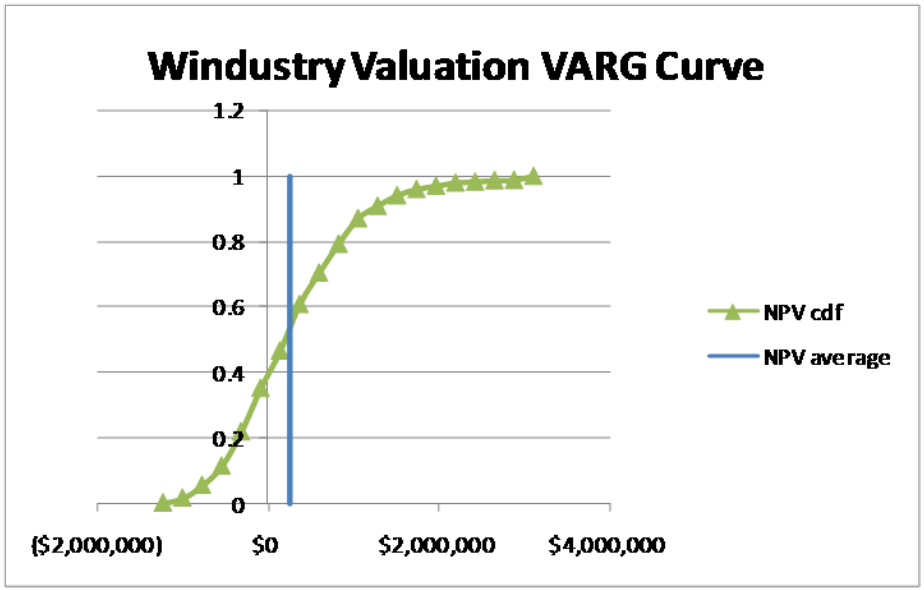
- Windustry results assuming deterministic revenue / cost profile for wind projects:
  - Using Wapakoneta capacity factor
  - Assuming PPA near current-day electricity price ($0.05 / kW-hr)
  - All other assumptions using deterministic values provided by Windustry tool

Project Summary	
Project Name	Test Project
Project Size (MW)	4.5
Turbine Model	GE 1.5MW
Net Capacity Factor (Years 1-20)	23%
Total kWh Produced (Years 1-20)	180,657,593
PPA	$0.0500
C-BED PPA (NPV)	$0.0000
Green Tag Rate	$0.0000
Total Installed Cost	$5,700,000
Local Investor Contribution	$2,000,000
Local Investor IRR	13%
Local Investor Return (NPV)	$430,058
Equity Investor Contribution	
Equity Investor IRR	
Equity Investor Return (NPV)	
O & M Rate (% of revenues)	11.1%
Capital Cost per kWh	$1,267
IRR (Years 1-20)	9%
Net Present Value (Years 1-20)	$130,058

Windustry Tool for Community Wind Planning: Augmentation with Real Options

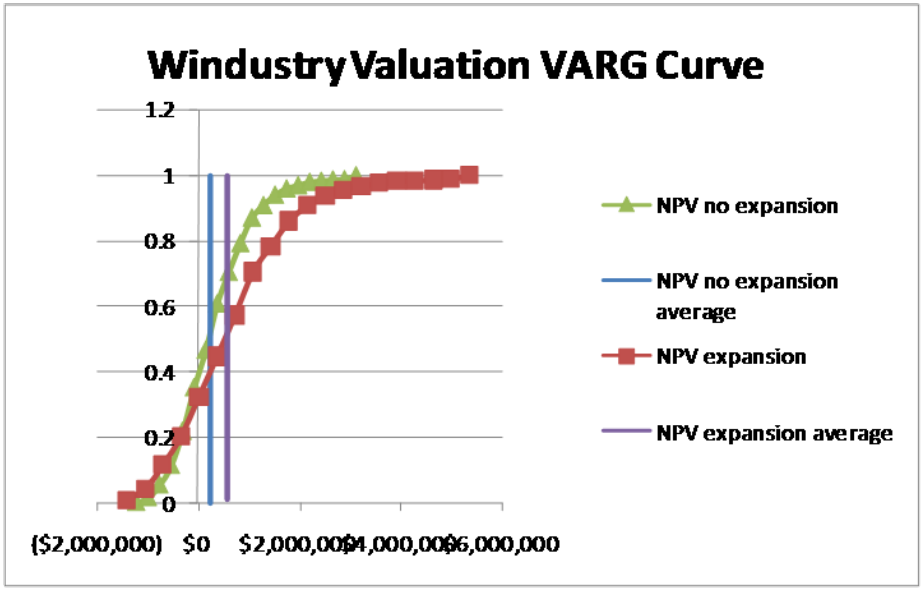
- Augmentation of Wind Project Calculator to Incorporate Uncertainty from Electricity Prices and Policy demonstrates distribution of outcomes:
  - Using same drift (0.02) in PPA as Windustry assumes and volatility as earlier (0.09), Monte Carlo simulations performed

	NPV 1
min	(1,451,556)
max	3,106,412
mean	248,314



Windustry Tool for Community Wind Planning: Augmentation with Real Options

> Re-evaluation of project economic feasibility through inclusion of simple deferral option for flexibility:



	NPV 1	NPV 2
min	(1,451,556)	(1,762,495)
max	3,106,412	5,337,946
mean	248,314	593,258

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Conclusions and Future Work

- Using community wind as an exemplary small-scale community energy planning project, various sources of uncertainty and opportunities for flexibility were identified
- Using a particular site in Ohio, one option of expansion was explored
- Initial analysis for a Wapakoneta wind project indicate that economies of scale are significant, but that the option for expansion still provides some value to the overall project
- Then, a survey was conducted and found that real options are not used presently for community wind projects
- Tools were incorporated into the windustry tool set which might hopefully promote usage and understanding of real options for community wind projects
- The analysis could be expanded to a larger toolset used for small-scale energy projects, even to residential solar

Q&A

> Thank you for your time!

Real Option Analysis 2: Shut-down

- Attempt to improve valuation of small-wind farm by including a put option to shut-down the small wind farm and sell off turbines if wholesale electricity prices do not rise as expected
- Pursue analysis using Binomial Tree Model
  - Using drift of 5.07% & volatility of 9.31%,
    - Upside factor = 1.0976
    - Downside factor = 0.9111
    - Upside probability = 0.7723
- Perform binomial tree analysis using above probability / price values and assuming:
  - Plant can be closed at any time
  - Turbines can be sold off to cover outstanding debt
  - Potential life of project in this case shortened to 15 years

Real Option Analysis 2: Shut-down

- Value of Option ~$700,000

	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	t = 6	t = 7	t = 8	t = 9	t = 10	t = 11	t = 12	t = 13	t = 14	t = 15
PV(Net Revenue)	585,185	894,774	865,316	828,789	670,674	396,250	56,160	365,687	645,387	883,087	1,066,292	1,180,375	1,208,156	1,129,511	920,939	555,051
WITH OPTIONS		946,549	923,436	894,774	865,316	828,789	675,000	412,034	130,257	129,317	349,060	516,837	618,819	638,771	557,688	353,380
(check next year)			973,342	949,549	923,436	894,774	865,316	828,789	734,000	484,827	346,820	33,372	129,606	231,404	256,150	185,971
				995,019	973,342	949,549	923,436	894,774	865,316	828,789	731,702	491,202	276,453	166,733	5,842	47,004
					1,014,769	995,019	973,342	949,549	923,436	894,774	865,316	828,789	813,599	587,463	291,941	66,354
						1,032,763	1,014,769	995,019	973,342	949,549	923,436	894,774	865,316	820,480	374,424	184,113
							1,049,138	1,032,763	1,014,769	995,019	973,342	949,549	923,436	813,910	517,802	243,603
								1,064,095	1,049,138	1,032,763	1,014,769	995,019	973,342	949,549	636,456	309,599
									1,077,704	1,064,095	1,049,138	1,032,763	1,014,769	995,019	736,118	364,364
										1,090,104	1,077,704	1,064,095	1,049,138	1,032,763	817,017	409,634
											1,101,401	1,090,104	1,077,704	1,064,095	885,003	447,378
												1,111,694	1,101,401	1,090,104	941,498	478,910
													1,121,072	1,111,694	988,265	504,319
														1,129,616	1,027,174	526,509
															1,059,455	544,431
																559,308

Value of option =	585,185
-	1,295,992
	710,807

- NPV of projects negative without production-tax-credits or other economic subsidies
- However, option still improves overall attractiveness of community wind project though it is not enough to cause the negative NPV project to become positive