Assessing the Economics of Renewable Generation

Donald N. Dewees
Professor Emeritus of Economics and Law
University of Toronto

Renewable Electricity Conference Calgary, Alberta

28 May 2015

Van Horne Institute

How to Evaluate Renewable Projects

- Economic evaluation of costs and benefits to the public from a renewable project.
  - Include environmental benefits.
  - Exclude subsidies – these are paid by the public.
- This is **not** how a developer decides whether to invest in a project.
  - Developer costs and revenue ignore environmental benefits, include subsidies, non-economic pricing
  - Developers know how to value cost and revenue.

Grid Parity News

- Good news: renewables have reached ‘grid parity’
  - Globe & Mail, ROB 12 March, 2015 Deutsche Bank says solar has reached ‘grid parity’ in 14 states.
  - Numerous similar headlines for renewables.
- Bad news: the supporting analysis is often not appropriate for policy evaluation.
  - Levelized cost is not appropriate for comparing dispatchable power with intermittent power.
  - Subsidies are often included.

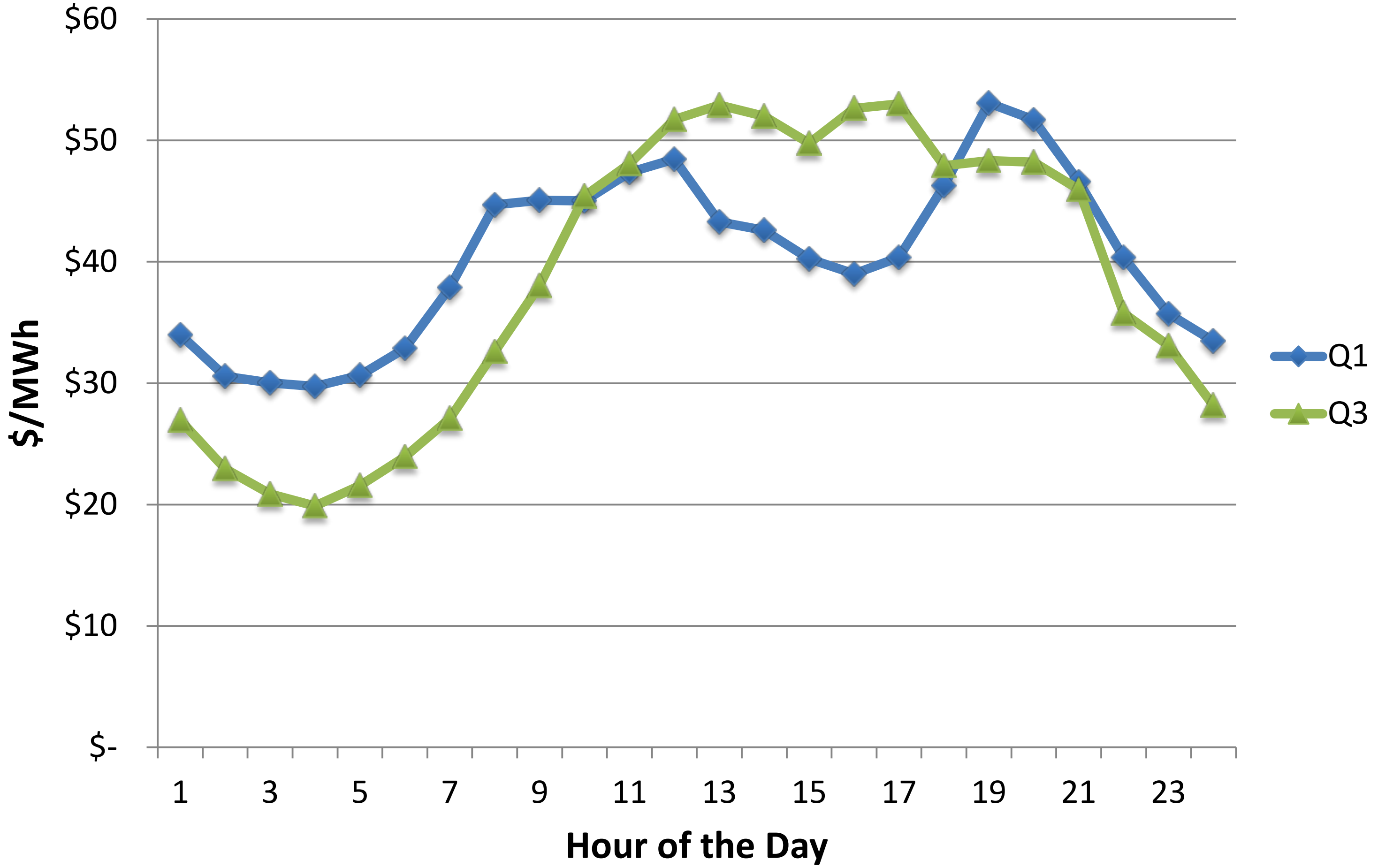
‘Levelized Cost Comparison’

- Levelized cost is the capital plus operating cost over the life of the plant per MWh generated.
- This is an appropriate method of comparing similar dispatchable technologies: coal vs gas.
  - If they have equal environmental effects.
- It is also appropriate if the value of every MWh is the same no matter when generated.
- But value varies by the hour.

Value of MWh Varies with Time

- Wholesale markets show that the value of generation (cost of alternatives) depends on **when** it is generated.
  - System operator pays more for peak period power than for off-peak power.
  - Spot price reflects the value (MC of alternatives).
- Comparing lifetime average cost/MWh ignores the **value** of the MWh.
- Economic comparison of generation considers its **cost** compared to its **value**.

Fig. 1 Ontario Spot Price (HOEP) Q1, Q3: 2006-2012



Value Matters for Intermittents

- Daytime value much more than night value.
- Winter and summer values differ.
- An intermittent that generates mostly during the peak is worth more than an intermittent that generates mostly off-peak.
  - Former displaces more costly dispatchable power.
- So, comparing LUEC does not tell what to build.

What is Value?

- Value is the avoided cost from conventional generation displaced:
  - Less fossil fuel burned (operating cost)
  - Less fossil capacity needed (capacity cost)
  - This is the cost savings part of ‘value’.
- Plus environmental values.
  - Discussed later

Cost Savings from Displaced Generation (The Hard Way, Best Way)

- Simulate the system capital plus operating cost that meets demand without the renewable.
- Determine renewable generation profile.
- Simulate the system cost with conventional output reduced to accommodate the renewable.
- Cost difference is the cost avoided by the renewable.

Savings Short Cut: History

- In a fully competitive system in equilibrium (rare), spot price indicates system marginal cost.
  - Recent spot price suggests the savings.
  - Look at recent history.
- In a competitive system with capacity markets or contracts, spot price is short run marginal cost but not long run (all-in) cost.
  - Consider both spot price and capacity costs.
  - Look at recent history.

Savings Short Cut: History (2)

- History is not a perfect guide to the future.
- Slow investment, long facility life mean the market may be out of long run equilibrium for years.
  - Any 5-year period may not predict next 5 years accurately, much less the next 20 years.
- So history short cut not as accurate as a forecast and simulation of the future system.

Simple Example 1

- Assume wholesale price history:
  - Off-peak = $40/MWh; peak = $80/MWh
- Assume wind blows only off peak.
  - Save $40/MWh operating cost.
  - No capacity savings since no peak contribution.
  - Value = $40/MWh (+ ENV values).
- Assume sun shines only on peak.
  - Save $80/MWh operating cost plus 0.4*peaking capacity cost/MWh (+ ENV values).

Simple Example Relevance

- Example 1 shows that value depends on **when** the renewable power is generated.
- Spot price history is a good guide to value of the renewable power if future will be like the past.
- History less useful if the future will be different:
  - Change in operating cost of marginal generation;
  - Shift in supply/demand balance from surplus to deficit (or vice-versa).
- How to account for future changes?

Middle Path: Adjusted History

- Start with spot price history to establish a baseline of price level and variation.
- Identify likely ways that future will be different.
  - Operating cost increase/decrease (fuel price?)
    - Estimate effect on spot price levels.
  - Supply/demand balance changes
    - Estimate effect on spot price levels.
    - Consider explicit capacity credit component.

Middle Path Example 2: Ontario

- Ontario has had excess capacity, so HOEP covers operating cost, not capital cost.
  - New power secured with long term contracts.
  - Most generator all-in cost & revenue > 2x HOEP.
- If excess supply persists, value of intermittent generation is just HOEP, no capacity value.
  - Adjust HOEP for gas price forecasts.
- If excess supply disappears (nukes retire) value of intermittent generation is HOEP plus a capacity credit for gas plants not built.
  - Estimate capital costs saved.

Summary: Cost Savings

- We have three ways to estimate cost savings from a renewable project:
  - Hard way: full system forecast and simulation;
  - Simple use of spot price history;
  - Middle path: history plus forecasts and adjustments.

Not Finished: Include Environment

- Comparing generation cost ignores the motive for renewables: environmental protection.
  - Reduced air pollution
  - Reduced GHG emissions
- We need an analysis that adds cost savings from renewable generation based on time plus the value of environmental attributes.
  - Value of air pollution avoided.
  - Value of GHG emissions avoided.

How to value the Environment?

- Model: Emissions → ambient concentration → health and environmental effects.
- Economic studies can value these effects.
  - What we pay to avoid them.
    - E.g. housing markets
  - What we are paid to accept them.
    - E.g. labour markets
- Results: $ harm/MWh electricity generated.
- Mostly health, depends on population density.

Table 1 Value of Air Pollution: Coal

Pollutant	Emission Rate Kg/MWh	Damage Rate $US/ton	Damage $CDN/MWh
SO_2	3.73	5,800	26.90
NO_x	1.24	1,300	2.00
PM_{10}	0.12	340	0.05
$PM_{2.5}$	0.038	7,100	0.34
Total			**$29.29**
Based on US EPA data, Great Lakes population density.			

Value of Air Pollution (3)

- Table1 shows $30/tonne pollution harm from each MWh of coal generation (EPA).
- Ontario studies suggested values from $130/MWh to $0.
- I use $30, consider $130.
- Similar analysis for natural gas generation yields $1.56/MWh or $6.76.
  – No SO2, little particulate.

Value of CO_2 Reduction

- What harm is caused by CO_2 emissions, per tonne?
  - Stern Review (2007) $38 to $111.
- What cost of policies to meet GHG goals?
  - Jaccard/Suzuki/Pembina (2009) $40 to $100.
  - NRTEE (2012) $150/tonne or more.
- What explicit costs imposed by policy?
  - BC carbon tax now $30/tonne
  - Federal 'Turning the Corner' $15/tonne.
- I use $25/T and $100/T as low and high values.

Table 2
Coal & Gas Environmental Costs

($/MWh Southern Ontario pollution values)

	Coal		Gas	
	Low	High	Low	High
Pollution*	30	130	1.56	6.76
CO2**	25	100	9.88	39.52
Total ENV Cost	55	230	11.44	46.28

* Low = USEPA values, high = DSS/RWDI 2005 values

** Low = $25/tonne; high = $100/tonne

Back to Big Picture

- Value of renewable resource is the sum of:
  - Savings from reduced conventional generation
    - Depends on timing of renewable generation.
  - Value of reduced air pollution
    - Depends on population density, season, wind patterns.
    - Much higher for displacing coal than gas.
  - Value of reduced GHG discharge
    - Location, timing does not matter.

Ontario Value Example: History

- Ontario spot price (HOEP) 2007-2012 indicates hourly cost of marginal generation = value of renewable MWh varying with time.
  - Average HOEP = $35.89.
  - Wind generation*hourly HOEP = 95% of unweighted HOEP: $34.10.
  - Solar generation elsewhere valued at 110% of system average spot price, yields $39.48.

Ontario Value Example (2)

- Ontario has excess capacity so HOEP does not cover capital costs.
  - If excess will persist, ignore capacity contribution.
- Capacity Credit Factor (CCF) = fraction of renewable capacity that displaces fossil.
  - % of wind or solar capacity we can rely on when system stressed.
  - Based on local experience or estimates.
- Ontario wind experience: $CCF_w = 0.11$
- Ontario solar experience: $CCF_s = 0.40$

Table 3: Ontario Value of Renewables Example

($/MWh generated, 2012 $, no inflation, displacing CCGT.)

	Biogas	Wind	Solar
Air pollution	1.56-6.76	1.56-6.76	1.56-6.76
Op cost save	35.89	34.10	39.48
Cap cost save	43.26	10.26	61.80
GHG at $25 - 100/ tonne	10-40	10-40	10-40
Total	91-126	56-91	113-148

Ontario Value of Renewables Example (4)

- Don't take these values for displaced generation too seriously:
  - Values depend on the generation displaced.
  - Values depend on timing:
    - demand load shape;
    - timing of renewables.
  - Capacity credit depends on whether new capacity will be needed.
    - Will nukes be refurbished or retired?

Subsidies Not Relevant

- This analysis is the value (benefits) to society of the renewables.
  - Not profit or loss for developer.
  - Not only impact on customers.
  - Looks at all costs, all benefits of renewables.
  - It excludes subsidies since these are just transfers from taxpayers to developers and/or consumers.
- This is not the business case analysis, this is the social benefit/cost analysis.

Values Vary Among Systems

- Values in these slides are examples only, simplified calculations, historical.
- Different service areas will have different costs.
- Blending historical spot prices with forecasts of fossil generation costs may yield better avoided cost estimates.
- Recent wholesale prices may represent short run excess supply or supply shortage.
  - For future analysis forecast likely supply/demand balance adjust values accordingly.

Implications for Procurement

- Estimate the value of the particular renewable considering the 3 elements discussed here.
- Match procurement prices to value.
  - Procurement prices should vary with time of day and season to match variations in generation costs saved.
  - Procurement prices could vary with location if environmental harm varies or because of grid constraints.
- Do not pay more than estimated value.
- ‘Net metering’ not a good procurement method.
  - Based on customer prices, ignores all 3 elements here.

Conclusions

- Do not compare intermittent renewables with fossil or other generation using levelized cost.
  - Need to consider time variations in value.
- Use the generation profile of the renewable, to estimate cost savings of displaced power on your system:
  - Operating cost savings;
  - Capital cost savings.

Conclusions (2)

- Include explicit environmental values based on empirical analysis.
  - Value of air pollution reduction depends on emission rates (fuel, technology) and population density.
  - Value of GHG reduction depends on emission rate and assumed value/tonne.
- Exclude subsidies when comparing cost of renewables with their value.
- Purchase renewables whose value exceeds their cost.