Some Issues of "Economic evaluation of environmental and energy resources"

Michele Moretto

Dept of Economics and Management

Levi Cases Retreat Day, January 18^{th}, 2016

PROJECT TITLE: Sustainability of introduction of pellet based heating systems in a mountain area (2y Research Grant)

.

- The aim of the study is to estimate the market value and optimal investment of pellet heating systems as compared with traditional ones. The project is divided in two main parts:
- 1) The aim of the first is to explore how types and key attributes of residential heating systems affect private homeowners' choices in renovations, by means of an econometric approach known as discrete choice modeling.
  - In particular, the goal is to investigate the potential switch from current traditional heating systems to a more environmental sustainable one, based on the use of pellet. Economic values expressed in terms of willingness to pay estimates of features towards sustainable heating systems will be computed.

PROJECT TITLE: Sustainability of introduction of pellet based heating systems in a mountain area (2y Research Grant)

.

- 2) The aim of the second part is to value the option to invest in the new and more sustainable technology. That is, in a framework where uncertainty and irreversibility make the traditional cost-benefit analysis inappropriate, the estimates of the willingness to pay to move from traditional heating systems to a pellet heating system are used to calibrate the value of the new technology and to calculate the expected time to reach it.
- In terms of policies, this value should be the tool to calculate the incentive to encourage early technology adoption.

PROJECT TITLE: Sustainability of introduction of pellet based heating systems in a mountain area (2y Research Grant)

.

- Preliminary econometric results, based on the estimation of discrete choice models, show that households preferences towards different heating systems in the Veneto are heterogeneous:
  - 20% of the share are for wood pellet, almost 20% for firewood, 16% for chip wood, 26% for methane, 9% for LP gas and only 8.5% for oil.
  - As expected, both investment and annual operating costs are statistically significant factors and the signs of their coefficients are negative.
  - The effect of CO_2 emissions is a significant and negatively affect the preferences for heating systems. In particular, the average WTP for the increase of 1kg/year of CO_2 emissions is –2.01€, suggesting a lower preference towards systems with high environmental impact.
- Finally, it is worth to say that the funds allocated underestimate the scope/magnitude of this research.

Reseach question # 1: The levelized cost is the best tool to evaluate intermittent power generation?

- Joskow, Paul L. 2011. "Comparing the Costs of Intermittent and Dispatchable Electricity Generating Technologies." American Economic Review, 101(3): 238-41.
- "Economic evaluations of alternative electric generating technologies typically rely on comparisons between their expected "levelized cost" per kWh supplied (LCOE). I demonstrate that this metric is inappropriate for comparing intermittent generating technologies like wind and solar with dispatchable generating technologies like nuclear, gas combined cycle, and coal. **It overvalues (the costs of) intermittent generating technologies compared to dispatchable base load generating technologies."** (p.238)
- A recent article in The Economist suggests that "standard 'levelized' calculations. . . are a poorway to compare fossil fuels and renewable energy" (The Economist, 2014). Similarly, Forbes magazine writes that the levelized cost of electricity is renewable energy's "ticking time bomb" (Pentland, 2014).

Reseach question # 1: The levelized cost is the best tool to evaluate intermittent power generation?

- The LCOE is calculated as the break-even price that investors would have to receive on average per kilowatt-hour (kWh) generated in order to cover all costs and receive an adequate return on their initial investment (i.e. a long-run average cost assuming a costant return to scale technolgy).
- In calculating this life-cycle cost, the vast majority of existing studies rely on **average capacity factors (CF)**, **that is, the average power generated by a particular facility in any given year**. For base-load natural gas power plants, this average capacity factor is typically specified in the range of 85–90% of the capacity theoretically available, with the remaining 10–15% accounting for scheduled maintenance.
- In contrast, the patterns of direct sun exposure limit the average capacity of solar PV installations to around 20–25% of theoretical capacity.

Reseach question # 1: The levelized cost is the best tool to evaluate intermittent power generation?

- The formula:

$$LCOE = \frac{I}{365 \cdot 24 \cdot CF \cdot \sum_{t=1}^{T} \frac{E_t}{1+r}}$$

- where I = Construction cost per kWp, T = useful life of the plant, E_t =the % of initial capacity that is still functional in year t, r = (financial) discount rate.

Reseach question # 1: The levelized cost is the best tool to evaluate intermittent power generation?

- An individual investor evaluating the profitability of an intermittent electricity generation facility, e.g., rooftop solar panels, should compare the LCOE with the flat rate price per kWh that it would alternatively have to pay for obtaining power from the grid.
- The intermettent power generation facility is cost competitve if:

$$p \geq LCOE$$

where $p = \frac{1}{365 \cdot 24} \sum_{j=1}^{365 \cdot 24} p_j$.

Reseach question # 1: The levelized cost is the best tool to evaluate intermittent power generation?

- However, if the investor faces a price schedule that varies by time of day and possibly also by season, the traditional LCOE calculation will generally fail to capture any synergies that arise if the solar facility generates power above its overall average predominantly at times when electricity prices are relatively high.
- In other words, there might be a (strong) correlation between p_j and CF within $[0, 24]$

Reseach question #.1: The levelized cost is the best tool to evaluate intermittent power generation?

Reichestein S. and Sahoo A. 2015, "Time of the day pricing and the levelized cost on intermittent power generation", Energy Economics, 48, 97-108.

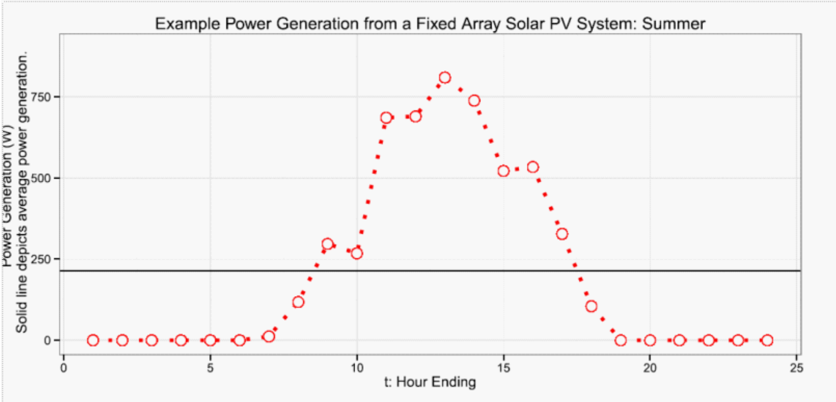

Fig. 1. Example generation curve for a fixed tilt array in San Francisco, CA (summer), assuming a 1 kW installation.

Reseach question #.1: The levelized cost is the best tool to evaluate intermittent power generation?

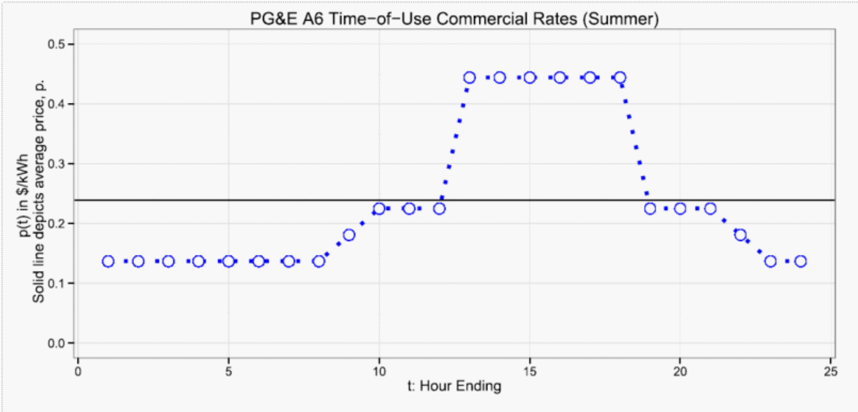

Fig. 3. Example PG&E A-6 time-of-use price curve (summer).

Reseach question # 2: The Value of the Smart Grid

- **Where is the value of smart grids?**
- Recent works has characterized the costs and benefits of individual "smart" investments.
- However, these works show that there is a mismatch between where benefits accrue and where costs are incurred, leading to a problem of value capture and redeployment.
- Further, some benefits of smart grids are less easy to price directly and can be classified as public goods, such as energy security and decarbonisation.

Reseach question # 2: The Value of the Smart Grid

- First of all, it is important to understand how, and to what extent, the development of the SG will affect the economic value of distributed renewable energy generation and energy-saving devices.
- Secondly, identify which market reforms and policy tools are required to link the development of the SG and the deployment of more environmental-friendly energy generation technologies into a coherent system.
- But, Where is the value for a private household?

- Example:
- Agent's demand of energy per unit of time $t > 0$ (i.e. day) is normalized to 1. This is can be represented as:

$$1 = \gamma\alpha_1 + \alpha_2$$

where $\alpha_1 > 0$ is the expected production of the power plant per unit of time, $\gamma \in [0,1]$ is the production quota used for self-consumption and $0 < \alpha_2 \leq 1$ is the energy bought from the national grid.

- If we consider as unit of time a day then $\gamma\alpha_1 + \alpha_2 \equiv \int_0^{24} l(t)dt = 1$ where $l(t)$ denotes the consumption of energy at time $t \in [0, 24]$.

Reseach question # 2: The Value of the Smart Grid

- $\alpha_2 \in [0, 1]$ is the quota of the energy demand that must necessarily be bought from the national grid, since it is required during the interval of plant inactivity (i.e. when solar radiations are not available),
- $\gamma\alpha_1 \in [0, 1]$ is the prosumed energy, when the plant is working and producing.
- $(1 - \gamma)\alpha_1$ is the quota the agent can sell on the local energy market.

Reseach question # 2: The Value of the Smart Grid

- Indicating by p the contract price (buying price) of energy,
- a the per unit cost paid to produce energy by the PV plant and
- v **the selling price of energy to a local SG**,
- The prosumer's net cost of energy per unit of time can be writen as:

$$\begin{aligned} C &= \min\left[p - \alpha_1(v-a), \quad \gamma\alpha_1 a + (1-\gamma\alpha_1)p - (1-\gamma)\alpha_1(v-a)\right] \\ &= p - \alpha_1(v-a) + \min[\gamma\alpha_1(v-p), \quad 0] \end{aligned}$$

- The second term is the typical payoff of a Financial-like Operational Switching Option.
- The value of this Option is the value of the SG for the prosumer and it should be maximized with respect to α_1.