

ELG4126- Sustainable Electrical Power Systems- DGD

Economics of Distributed Resources

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Outline

- Introduction to Energy Economics
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 - Demand Charges
 - Demand Charges with a Ratchet Adjustment
 - Load Factor
 - Real-Time Pricing



Introduction to Energy Economics



- History
 - 1865 The coal question
 - 1973 Oil crisis

- Definition
 - Scientific subject
 - Related to supply and use of energy in societies
 - An applied sub-discipline of economics



Main Topics of Economics



- Main topics of economics related to energy economics
 - Econometrics
 - Environmental Economics
 - Finance
 - Industrial Organization
 - Microeconomics
 - Macroeconomics
 - Resource Economics
 - Results of Energy Engineering, Geology, Political Sciences, Ecology

Distributed Resources (DR)



- Traditional Focus
 - Generating resources, forecasting the demand
 - Trying to select the most cost-effective combination of new power plant
- Recently
 - Real need: energy services, e.g. illumination, not raw kilowatt-hours
- Integrated Resource Planning (IRP)
 - Both supply side and demand side resources
 - Environmental and social cost
 - Least cost plan to meet the wants and the needs





Cogeneration- High Efficiency

- The usable waste heat is incorporated into the energy conversion processes
 - Low temperature (50-80⁰C)
 - Water heating
 - Space heating
 - Medium temperature (80-100⁰C)
 - Space heating
 - Air conditioning
 - High temperature (over 100⁰C)
 - Process heating
 - Industrial purposes



Distributed Resources (DR)



- Small in scale and located somewhat near the end-user
- Distributed Generation
 - Fuel cells
 - Internal combustion engines
 - Combustion turbines
 - Biomass cogeneration
 - Wind turbines
 - Photovoltaic
 - Mini-hydro



Distributed Resources (DR)



- Small in scale and located somewhat near the end-user
- Grid Resources: *move electricity from generators to customers*
 - Increased grid capacity
 - Decreased grid losses
 - Grid-sited storage
 - Improved power factor
 - Reduced connection losses
 - Unaccounted for losses



Distributed Resources (DR)



- Small in scale and located somewhat near the end-user
- Demand-Side Resources: *link electricity to energy services*
 - Heat pumps
 - Solar architecture
 - Motor controls
 - Efficient lighting
 - Load shifting
 - Appliance efficiency
 - Absorption cooling





Electric Utility Rate Structures

- Essential step for any economic calculation for a DR:
 - Careful analysis of
 - The cost of electricity
 - The cost of fuel
- Electric utility rate structures:
 - Critical factors for customers evaluating a DR project intended to reduce electricity purchases.
- Variation of electric rates:
 - Utility
 - Electrical characteristics of the specific customer





Standard Residential Rates

- Table 1. Example rate structure for a residential customer

Tier Level	Winter: November–April		Summer: May–October	
Tier I	First 620kWh	7.378¢/kWh	First 700kWh	8.058¢/kWh
Tier II	621–825	12.995¢/kWh	701–1000	13.965¢/kWh
Tier III	Over 825	14.231¢/kWh	Over 1000	15.688¢/kWh

- Above example, recent Residential Rates: *Inverted block rate structure*
- Previously: *Declining block rates*, which made electricity cheaper as the customer’s demand increased.



Residential Time-Of-Use (TOU) Rates

- Table 2. Example of a residential TOU rate schedule for a summer-peaking utility

	November–April		May–October	
On-peak	7–10 A.M., 5–8 P.M.	8.335 ¢/kWh	2–8 P.M.	19.793 ¢/kWh
Off-peak	All other times	7.491 ¢/kWh	All other times	8.514 ¢/kWh

- Careful calculation would need to be made to determine whether the TOU rate or the regular residential rate would be most cost-effective for an individual homeowner



Demand Charges

- Table 3. Example of a typical rate structure with demand charge

	Winter Oct–May	Summer June–Sept
Energy charges	\$0.0625/kWh	\$0.0732/kWh
Demand charges	\$7/mo-kW	\$9/mo-kW

- Based on the peak demand in a given month
- Usually averaged over a 15-minute period

Demand Charges with a Ratchet Adjustment



- Problem of demand charges:
 - Monetarily significant for just one month of the year
 - Not sufficient for the utility to pay for the peaking power plant they had to build to supply the load
- Solution:
 - Having a ratchet adjustment built into the demand charges
- Benefits:
 - Extraordinary penalties for customers who add a few kilowatts to their load right at the time of their annual peak.
 - Provides considerable incentive to reduce those customers highest peak demand.





Load Factor

- Definition:
 - The ratio of a customer's average power demand to its peak demand
- Benefit:
 - Useful way for utilities to characterize the cost of providing power to that customer
- Formula:

$$\text{Load factor (\%)} = \frac{\text{Average power}}{\text{Peak power}} \times 100\%$$





Real-Time Pricing (RTP)

- Shortcomings of TOU
 - Relatively crude since they only differentiate between relatively large blocks of time (peak, partial-peak, and off-peak, for example)
 - Typically only acknowledge two seasons: summer and non-summer.
- Definition of RTP:
 - True cost of energy
 - Reflected in rates that change throughout the day, each and every day.
- Benefit of RTP:
 - No demand charges, just energy charges that might vary, for example, on an hourly basis.



Example 1: Calculating a Simple Residential Utility Bill



- Q: Customer subject to the rate structure in Table 1 uses 1200 kWh/mo during the summer.
 - What would be the total cost of electricity
 - What would be the value (¢/kWh) of an efficiency project that cuts the demand to 900 kWh/mo?
- *Answer:*
 - The total monthly bill includes 700 kWh @ 8.058¢, 300 kWh @ 13.965¢, and 200 kWh @ 15.688¢, for a total of
$$700 * \$0.08058 + 300 * \$0.13965 + 200 * \$0.15688 = \$129.68 / \text{mo}$$
 - If the demand is reduced to 900 kWh/mo, the bill would
$$700 * \$0.08058 + 200 * \$0.13965 = \$84.34 / \text{mo}$$
 - Savings per kWh is $(\$129.68 - \$84.34) / 300 \text{ kWh} = \$0.1511 / \text{kWh}$

Example 2: PVs, TOU Rates, and Net Metering



- Q: Based on the table below, for a 30-day month in the summer, find the electric bill for the customer if the TOU rates of Table 2 apply.

	PV supply	Demand
On-peak	10kWh	2kWh
Off-peak	10kWh	18kWh
Total	20kWh/day	20kWh/day

- Answer:*
 - On-peak credits = $8 \text{ kWh/day} * \$0.19793 / \text{kWh} * 30 \text{ day/mo} = \47.50
 - Off-peak bill = $8 \text{ kWh/day} * \$0.08514 / \text{kWh} * 30 \text{ day/m} = \$20.43/\text{m}$
 - Net bill = $\$20.43 - \$47.50 = - \$27.07\text{mo}$

Example 3: Impact of Demand Charges



- Q: During the summer, a small commercial building that uses 20,000 kWh per month has a peak demand of 100 kW
 - The monthly bill?
 - How much does the electricity cost for a 100-W computer that is used 6h a day for 22 days in the month? The computer is turned on during the period when the peak demand is reached for the building. How much is that in ¢/kWh?

(Based on Table 3)



Example 3: Impact of Demand Charges

Answer:

- Monthly bill = energy charges + demand charges
 - Energy charge = $20,000 \text{ kWh} * \$0.0732/ \text{ kWh} = \$1464/ \text{ mo}$
 - Demand charge = $100 \text{ kW} * \$9/ \text{ mo-kW} = \$900/ \text{ mo}$
 - For a total of $\$1464 + \$900 = \$2364/ \text{ mo}$
- The computer uses $0.10 \text{ kW} * 6 \text{ h/ d} * 22 \text{ day/ mo} = 13.2 \text{ kWh/ mo}$
 - Energy charge = $13.2 \text{ kWh/ mo} * \$0.0732/ \text{ kWh} = \$0.97/ \text{ mo}$
 - Demand charge = $0.10 \text{ kW} * \$9/ \text{ mo-kW} = \$0.90/ \text{ mo}$
 - Total cost = $\$0.97 + \$0.90 = \$1.87/ \text{ mo}$
 - Per kilowatt-hour basis: $(\$1.87/ \text{ mo}) / (13.2 \text{ kWh/ mo}) = \$0.142/ \text{ kWh}$

Example 4: Impact of Ratcheted Demand Charges on an Efficiency Project



- Q: A customer's highest demand for power comes in August when it reaches 100 kW. The peak in every other month is less than 70 kW. A proposal to dim the lights for 3 h during each of the 22 workdays in August will reduce the August peak by 10 kW. The utility's energy charge is 8¢/kWh and its demand charge is \$9/kW-mo with an 80% ratchet on the demand charges.
 - a. What is the current annual cost due to demand charges?
 - b. What annual savings in demand and energy charges will result from dimming the lights?
 - c. What is the equivalent savings expressed in ¢/kWh?

Example 4: Impact of Ratcheted Demand Charges on an Efficiency Project



Answer:

a)

- At \$9/kW-mo, the current demand charge in August will be

$$\text{August} = 100 \text{ kW} * \$9/ \text{ kW-mo} = \$900$$

- For the other 11 months, the minimum demand charge will be based on 80 kW, which is higher than the actual demand:

$$\text{Sept–July demand charge} = 0.8 * 100 \text{ kW} * \$9/ \text{ kW-mo} * 11 \text{ mo} = \$7920$$

- So the total annual demand charge will be

$$\text{Annual} = \$900 + \$7920 = \$8820$$



Example 4: Impact of Ratcheted Demand Charges on an Efficiency Project



Answer:

b)

- August = $90 \text{ kW} * \$9/ \text{ kW-mo} = \810
- Sept–July = $0.8 * 90 \text{ kW} * \$9/ \text{ kW-mo} * 11 \text{ mo} = \7128
- Total annual demand charge = $\$810 + \$7128 = \$7938$
- Annual demand savings = $\$8820 - \$7938 = \$882$
- August energy savings = $3 \text{ h/d} * 10 \text{ kW} * 22 \text{ days} * \$0.08 = \$52.80$
- Total Annual Savings = $\$882 + \$52.80 = \$934.80$

- Notice that the demand savings is 94.4% of the total savings!

Example 4: Impact of Ratcheted Demand Charges on an Efficiency Project



Answer:

c)

- Dimming the lights saved $3 \text{ h/d} * 10 \text{ kW} * 22 \text{ d} = 660 \text{ kWh}$ and \$934.80 which on a per kWh basis is

$$\text{Savings: } (\$934.80) / (660 \text{ kWh}) = \$1.42/\text{kWh}$$

- In other words, the business saves \$1.42 for each kWh that it saves, which is about 18 times more than would be expected if just the \$0.08/kWh cost of energy is considered.



Example 5: Impact of Load Factor on Electricity Costs



- Q: Two customers each use 100,000 kWh/mo. One (customer A) has a load factor of 15% and the other (customer B) has a 60% load factor. Using a rate structure with energy charges of \$0.06/kWh and demand charges of \$10/kW-mo, compare their monthly utility bills.
- *Answer:* They both have the same energy costs: $100,000 \text{ kWh/mo} * \$0.06/\text{kWh} = \$6000/\text{mo}$. Based on the load factor formula we have:
 - $\text{Peak(A)} = (100,000 \text{ kWh/mo}) / (15\% * 24 \text{ h/day} * 30 \text{ day/mo}) * 100\% = 925.9 \text{ Kw}$, Costing = \$9259/mo
 - $\text{Peak(B)} = (100,000 \text{ kWh/mo}) / (60\% * 24 \text{ h/day} * 30 \text{ day/mo}) * 100\% = 231.5 \text{ Kw}$, Costing = \$2315/mo
 - The total monthly bill for A with the poor load factor is nearly twice as high as for B (\$15,259 for A and \$8315 for B)

Journal Paper of the week



Maria Isabel Blanco, “*The Economics of Wind Energy*”,
Renewable and Sustainable Energy Reviews, Elsevier, 2009



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