Economics of Electricity

**Watts up? kW versus kWh**

- A kWh is a measure of energy - how much fuel is used by something over a period of time.
- Similarly, BTUs, Calories, therms, and Joules are measures of energy.
- Electricity supplies energy in a form that can be used to run appliances, machines, etc.
- However, expressing energy in terms of kWh doesn’t mean much unless we know the time period over which it was measured.
- And to comparisons of kWh consumption requires standardization on the time periods involved.

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**Power**

- A kW is a measure of power - the rate at which energy is converted from one form into another.
- Joules per second and Watts are the same thing: $1 \text{ W} = 1 \text{ J/sec}$
- A kilowatt is 1000 watts ($[\text{W} = 0.001 \text{ kW}]$)
- A 3 kW wind turbine is capable of generating 3 kW of power; the rate at which it can generate energy; not the amount of energy it can generate.
- A 60 W light bulb “uses” 60 W of power when it is turned on.
- It doesn’t matter how long it’s turned on; when it’s on it’s using 60 W of power, when it’s off it’s using 0 W.

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**From Joules [Watts] to $$$$**

- To put an economic value on power we need to know how long it is being generated/consumed.
- “Energy consumption” ≡ average power [a.k.a. “load” or “demand”] $\text{Energy [kWh]} = \text{Power [kW]} \times \text{Time [h]}$
- 1 kW over a 30 minute period = 1 * 0.5 = 0.5 kWh
- Check your understanding of the difference between kW and kWh:
  - 1 kWh over a 30 minute period = 1 kWh
- Calculate $$ by multiplying kWh consumption by price per kWh.

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**Electricity Pricing Schemes**

- Prices can change over time (PUC approved rate changes; monthly in some situations).
- Prices can change by time of day.
- Prices can vary by maximum (“peak”) demand.
- Block pricing.
- Taxes.
- Incentive programs to reduce consumption; ‘nudges’.
- “Green” power [See https://megreenpower.com/overview].
  - 1.5 cents more per kWh; purchased in “blocks”, Maine-based renewable energy.

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** Bioshelter Electricity Use**

- Pick a 24-hr period: March 6, 2015.
- At 0:05am I recorded 28.52 Wh ($[(342.24 \text{ W})\times(1/12 \text{ h})]$).
- At 6:25am I recorded 1,163.89 W or 96.99 Wh.
- Total Wh for March 6th: 6,884.47 Wh or 6.88447 kWh.
- Average price of electricity: $0.158.
- March 6th cost me $1.09 (about $33 per month × 5 months = $165/yr).
A ‘typical’ residential electric bill

- Information on the bill
- ‘Standard offer’
- Green Power options
- 75 “Competitive Electricity Providers” for CMP residential customers

Maine Green Power allows you to select the participation level that best suits your home or business: 1 block = 250 kWh per month - $3.75 (available to residential customers only)
2 blocks = 500 kWh per month - $7.50 (roughly equivalent to the average household’s usage)
3 blocks = 1,000 kWh per month - $13
3+ blocks = Residential customers are limited to 4 blocks (at $7.50 each), but businesses can set their desired level.

Marginalism

- Thinking like an economist means evaluating behavior “…at the margin”
- Your decision to prepare now for your midterm next week isn’t about whether or not to study at all …
- …it’s about whether to devote an extra hour to working on this course versus an hour at the gym, or playing a video game, or spending time with your friends
- Your answer to this dilemma will likely be different this week than, say, next Thursday evening as the opportunity cost of not studying increases

Production

Assume diminishing marginal products for at least some factors of production
Marginal product of labor
- Amount of additional output you get from employing one additional worker for a fixed stock of capital
- Slope of the production function
- Marginal product of the first worker is greater than the 100th worker

Costs of production

Fixed costs (FC)
- Do not vary with the quantity of output produced
- Incurred even if the firm produces nothing at all
- Examples: rent on office space; insurance premiums; generators; fan gas scrubbers (a.k.a., “sink” costs)
Variable costs (VC)
- A function of the level of output
- Examples: unit labor costs; fuel costs
Explicit costs
- Require no outlay of money from the firm
- Examples: opportunity cost; reputation effects; brand loyalty
Average & Marginal Costs

- Average total cost
  - Average fixed cost + average variable cost
  - \( \text{ATC} = \frac{\text{TC}}{Q} \)
  - Cost of producing a typical unit of output
- Marginal cost
  - Change in total cost / Change in output
  - \( \text{MC} = \frac{\Delta \text{TC}}{\Delta Q} \)
  - Cost of increasing production by one additional unit
  - \( \text{MC} \) equals ATC at the minimum point on the ATC curve

Competitive Markets

- Three key characteristics
  1. Many buyers and sellers
  2. Homogenous goods and services
  3. No barriers to entry/exit
- Result: the actions of a single buyer or seller will not impact the equilibrium market price

Monopoly

- Barriers to entry cause monopolies
  - Only one seller/producer
  - Other firms cannot enter the market because they can’t compete with it
  - Three main reasons why monopolies arise:
    1. A key resource is owned by a single firm
    2. Government gives exclusive rights to produce a good or service
    3. Costs of production make a single producer more efficient than a large number of producers

Other market structures

Oligopoly
- Only a few sellers, each offering a similar product
- Examples: athletic equipment; crude oil (OPEC)

Monopolistic competition
- Many firms selling similar, but not identical products
- Examples: e-book sellers; digital music; computer games; movies

Firm revenue

- All firms:
  - Total revenue: \( TR = P \times Q \)
  - Average revenue: \( AR = \frac{TR}{Q} \)
  - Marginal revenue: \( MR = \frac{\Delta TR}{\Delta Q} \)
  - Profit = total revenue - total cost
- Firms operating in competitive markets:
  - \( P \) is determined by the market and does not vary with \( Q \)
  - A 1 unit increase in \( Q \) increases total revenue by \( SP \)
  - Therefore, \( MR = P \)

Profit maximization

- Economic profit: total revenue minus all of the opportunity costs (implicit and explicit) of producing the goods and services it sells
- Accounting profit: total revenue minus total cost
- Profit maximization occurs when \( MR = MC = P \)
- Proof by contradiction [*suppose not*]:
  - Suppose \( MR < MC \): firm will reduce output since each additional unit costs more than it earns in revenue; marginal cost falls; profit increases
  - Suppose \( MR > MC \): firm will increase output since each additional unit earns more than it costs; marginal cost increases; profit increases
  - When \( MR = MC \) the competitive firm will no longer have an incentive to change output
Geometry of profit maximization

- MR equals the market price
- AR = \( \frac{P \times Q}{Q} = P = MR \)
- MR > MC, so the firm can increase profit by increasing output
- MR < MC, so the firm can increase profit by decreasing output
- Profit is maximized when MC = MR at \( Q_{max} \)

Competitive Firm’s Supply Curve

- The marginal cost curve illustrates the quantity supplied by the firm at any given price
- Therefore, the MC curve is the competitive firm’s supply curve
- For the competitive firm, the price of its output is pre-determined
- Therefore, \( MR = SP \)
- An increase in price (say, due to an increase in demand) causes MR > MC and the firm will respond by increasing Q to increase profit

Shut-down decision

- The competitive firm ignores fixed costs in the decision whether or not to shut down
- As long as the firm can cover its variable costs, it will remain in business
- Algebra:
  - Shut down if \( TR < VC \) or if \( TR/Q < VC/Q \)
  - Since \( TR/Q = AR = P \) and \( VC/Q = AVC \)
  - Shut down if \( P < AVC \)

Marginal Revenue for the Monopolist

- The monopolist’s marginal revenue is always less than the price of its output because it faces a downward sloping demand curve
- To increase output, the monopolist must lower its price
- Thus, the monopolist’s marginal revenue will always be less than its price
- \( MR = \frac{\Delta TR}{\Delta Q} \)
- When the monopolist increases output, there are two effects on \( \Delta TR \):
  1. TR increases due to the increase in Q, but
  2. TR decreases due to the decrease in P
- If Q gets large enough, the negative price effect can outweigh the positive output effect causing MR to become negative

Monopolies

- Monopolies can control the price of its output by adjusting the quantity it supplies to its market
- Competitive firms have no control over price because they are small relative to the market
- The competitive firm’s demand curve is equal to the market price (perfectly elastic)
- The monopolist’s demand curve is the market demand curve
- Thus, market demand constrains the monopolist’s production possibilities
- A monopolist can choose to produce at any point on the market demand curve
Profit maximization for the monopolist

- Profit maximization once again occurs at the point where MR = MC.
- But for the monopolist, P > MR.

Problems with monopolies

- Inefficient allocation of resources.
- Socially efficient level of output occurs where the demand curve intersects the marginal cost curve.
- The value to consumers (willingness to pay) equals the cost to the monopolist.
- But the monopolist produces less than the socially efficient quantity of output.
- Result is a deadweight loss to society.

Government responses

1. Antitrust Laws designed to increase competition.
2. Regulation of prices:
   - Unique challenge with natural monopolies.
   - Setting P=MC means the monopolist loses money.
   - Subsidies must be offset through higher taxes.
   - Setting P=ATC means zero economic profit and no incentive for the monopolist to reduce costs through innovation or investments that increase productivity.
3. Turn the private monopoly into a public corporation (e.g., the U.S. Postal Service).
4. Do nothing.