Lecture # 19 -- Case #2: Water Pricing

Case #2: Water Pricing in Akvo

- Goal: To find a water pricing scheme for a small city in a middle-income country.
    - Water is currently subsidized, costing the community money.
    - You have been asked to consider several alternatives for raising the price to reduce the cost to the community.
    - Note that water delivery as features of a natural monopoly
        - There are high fixed costs, so that the average cost of providing water is always falling.
- Current policy
    - All households pay $0.3/m^3.
    - From the chart, we see that total demand will be 307,500
    - Use demand curve for each type of household to find consumption for each.
        - Low income:
            - $Q_L = 6.25 – 3.75P$
            - $Q_L = 6.25 – 3.75(0.3) = 5.125$
        - High income:
            - $Q_H = 62.5 – 37.5P$
            - $Q_H = 62.5 – 37.5(0.3) = 51.25$
    - Note that we can verify total demand as follows.
        - To get total water consumption, note that there are 10,000 low-income households and 5,000 high-income households:
        - Total consumed by low-income households:
            - 10,000 x 5.125 = 51,250
        - Total consumed by high-income households:
            - 5,000 x 51.25 = 256,250
        - Total consumed:
            - = 51,250 + 256,250
            - = 307,500
    - Revenue, costs, and profits
        - Total revenue
            - 0.3x307,500 = $92,250
        - Total costs
            - =0.6x307,500 + 35,000 = $219,500
        - Profits = Total revenue – total costs
            - = $-127,250

- Option 1: Marginal cost pricing
  - All households pay $0.6/m^3$.
  - From the chart, we see that total demand will be 240,000
  - Use demand curve for each type of household to find consumption for each.
    - Low income:
      - $Q_L = 6.25 – 3.75P$
      - $Q_L = 6.25 – 3.75(0.6) = 4$
    - High income:
      - $Q_H = 62.5 – 37.5P$
      - $Q_H = 62.5 – 37.5(0.6) = 40$
  - Note that we can verify total demand as follows.
    - To get total water consumption, note that there are 10,000 low-income households and 5,000 high-income households:
    - Total consumed by low-income households:
      - 10,000 x 4 = 40,000
    - Total consumed by high-income households:
      - 5,000 x 40 = 200,000
    - Total consumed:
      - = 40,000 + 200,000
      - = 240,000
  - Revenue, costs, and profits
    - Total revenue
      - 0.6x240,000= $144,000
    - Total costs
      - =0.6x307,500 + 35,000 = $179,000
    - Profits = Total revenue – total costs
      - = $-35,000
    - Note that, since marginal costs are constant, the loss exactly equals the fixed costs.
      - Intuitively, the price charged covers all the variable costs of water provision, but does not cover the fixed cost.

- Option 2: Privatization
  - The privately held firm will maximize profits.
  - Profits are maximized where MR = MC.
    - Since water provision is a natural monopoly, note that MR < P.
  - From the table, we cannot find a price where MR exactly equals MC. Thus, we look for the last price where MR > MC.
    - This is a price of $\$1.1/m^3$.
  - From the chart, we see that total demand will be 127,500.
  - Use demand curve for each type of household to find consumption for each.
    - Low income:
      - $Q_L = 6.25 – 3.75P$
      - $Q_L = 6.25 – 3.75(1.1) = 2.125$
    - High income:
      - $Q_H = 62.5 – 37.5P$
      - $Q_H = 62.5 – 37.5(1.1) = 21.25$
  - Note that we can verify total demand as follows.
    - To get total water consumption, note that there are 10,000 low-income households and 5,000 high-income households:
    - Total consumed by low-income households:
      - 10,000 x 2.125 = 21,250
    - Total consumed by high-income households:
      - 5,000 x 2.125 = 106,250
    - Total consumed:
      - = 21,250 + 106,250
      - = 127,500
  - Revenue, costs, and profits
    - Total revenue
      - 1.1x127,500= $140,250
    - Total costs
      - =0.6x127,500 + 35,000 = $111,500
    - Profits = Total revenue – total costs
      - = $28,750

- Option 3: Break-even pricing
  - To find a price where the water utility breaks even we use average cost pricing.
    - For average cost pricing, we find where price equals average cost.
  - Since there is no price exactly equaling average cost in the chart, we look for the lowest possible price that exceeds average cost.
    - That is, we want any profits to be as small as possible
    - This occurs at a price of $0.8/m^3$.
  - From the chart, we see that total demand will be 195,000
  - Use demand curve for each type of household to find consumption for each.
    - Low income:
    - $Q_L = 6.25 – 3.75P$
    - $Q_L = 6.25 – 3.75(0.8) = 3.25$
    - High income:
    - $Q_H = 62.5 – 37.5P$
    - $Q_H = 62.5 – 37.5(0.8) = 32.5$
  - Note that we can verify total demand as follows.
    - To get total water consumption, note that there are 10,000 low-income households and 5,000 high-income households:
    - Total consumed by low-income households:
      - 10,000 x 3.25 = 32,500
    - Total consumed by high-income households:
      - 5,000 x 32.5 = 162,500
    - Total consumed:
      - = 32,500 + 162,500
      - = 195,000
  - Revenue, costs, and profits
    - Total revenue
      - 0.8x195,000= $156,000
    - Total costs
      - =0.6x195,000 + 35,000 = $152,000
    - Profits = Total revenue – total costs
      - = $4,000

- Option 4: Minimum allotment
    - This policy has multiple goals:
        - Each family must receive at least the $4m^3$ of water per month necessary for survival.
        - The water utility must cover all costs on its own, so that the government need not subsidize the utility.
    - Note that none of the other options meet this goal.
        - The only strategies in which low-income families receive at least $4m^3$ of water are the current subsidy or marginal cost pricing. Both result in the water utility losing money.
    - Thus, we will need to use some form of price discrimination to meet both goals.
        - We know that demand for low-income families equals the minimum allotment at the marginal cost of $\$0.6/m^3$. Thus, low-income families cannot be charged more than this price.
        - However, we also know that if we charge high-income families this same price, the utility will lose money.
            - Thus, high-income families must pay more.
            - Policy options include:
                - Price discrimination using tiered pricing
                    - Charging the marginal cost of $0.6/m^3$ for the first $4m^3$, and a higher price for anything above that quantity.
                    - The higher price should be high enough to allow the utility to at least break even.
                - Price discrimination based on income
                    - Charge low-income users the marginal cost, and charge a higher price to high-income families.
                - Two-part tariff
                    - Charge users the marginal cost for water, but also include a fixed connection fee that covers the fixed costs.
                    - Low-income families could be exempted from this connection fee.

- These options are more complicated to calculate, since they involve different prices for different groups. The most straightforward is the two-part tariff.
  - Since the per-unit charge equals marginal costs, we already know the consumption for each group.
    - Low income: $4m^3$
    - High income: $40m^3$
    - Profit from marginal cost pricing = -$35,000
  - Since the marginal cost pricing exactly covers the variable costs of water supply, the connection fee just needs to cover the fixed costs.
    - If we only charge the connection fee to high-income families, $35,000 must be raised from 5,000 households.
    - Thus, the charge per household is $35,000/5,000 = $7.
  - Note that this assumes high-income consumption doesn't change as a result of the connection fee.
    - This is probably a reasonable assumption. It would change if there were an income effect – if demand fell because household income is lower after the connection fee.
    - However, since the connection fee is small, the income effect is likely negligible.
- Alternatively, we can examine one of the price discrimination options by first calculating the revenue raised from sales at $0.6/m^3$ and then finding a price for the remaining demand that satisfies
  - Price discrimination based on income
    - We know that low income users will be charged $\$0.6/m^3$ and will consume $4m^3$
      - Ignoring fixed costs, the utility breaks even on these customers.
    - Thus, we need a price that generates at least $35,000 of profit from high income consumers in order to break even.
      - As I showed in class, this is easiest to do using a spreadsheet. We can simply try prices until finding one that generates at least $35,000 of profit based on the variable costs.
    - To do by hand, we know that the price for low-income consumers must be $\$0.6/m^3$. We'll need a high-enough price for high income consumers to cover our losses on this group.
      - That price must be higher than the break-even price of $\$0.8/m^3$. So, begin by trying a price of $\$0.9/m^3$ for high income households:
        - $Q_H = 62.5 – 37.5P$
        - $Q_H = 62.5 – 37.5(0.9) = 28.75$
      - Now we can get total demand and find total costs that we can verify total demand as follows.

            - To get total water consumption, note that there are 10,000 low-income households and 5,000 high-income households:
                - Total consumed by low-income households:
                    - 10,000 x 4 = 40,000
                - Total consumed by high-income households:
                    - 5,000 x 28.75 = 143,750
                - Total consumed:
                    - = 40,000 + 143,750
                    - = 183,750
        - Revenue, cost, and profits
            - Total revenue
                - 0.6x40,000 + 0.9x143,750= $153,375
            - Total costs
                - =0.6x183,750 + 35,000 = $145,250
            - Profits = Total revenue – total costs
                - = $8,125
- Two-tiered pricing
    - Calculating the resulting revenue for this option is slightly more complicated
    - We can still use the demand curve to find the quantity of water consumed.
        - To see why, consider how high-income households respond to each price.
        - High-income households get their first 4m^3 for $0.6. To analyze their demand with a higher price, we could subtract 4 from their demand to account for the 4m^3 they already have. The residual demand is Q_H = 58.5 – 37.5P.
        - But to get their total water consumption, we add back in the 4m^3 purchased at $0.6. That brings us back to the original demand curve of 62.5-37.5P.
    - Using a spreadsheet, we can now find a price that allows the utility to break even, or as before, use trial and error to find a price.
    - Again, we try 0.9/m^3 for the second tier
        - Total demand for high-income families:
            - = 62.5-37.5(0.9) = 28.75
        - Total demand
            - Low-income: 40,000
            - High-income: 28.75*5,000 = 143,750
            - Total: 183,750
        - While this is the same quantity as above, profits will be somewhat different:

- Total revenue must consider the two prices:
  - 0.6x40,000 + 0.6x4x5,000 + 0.9x24.75*5000= $147,375
- Total costs
  - =0.6x183,750 + 35,000 = $145,250
- Profits = Total revenue – total costs = $2,125

- To summarize:

	Current	MC pricing	Privatization	Break-even	Minimum allotment
Price (per m^3)	0.3	0.6	1.1	0.8	0.6 (low) 0.9(high)
Low-income usage	5.125	4	2.125	3.25	4
High-income usage	51.25	40	21.25	32.5	28.75
Total consumption	307,500	240,000	127,500	195,000	183,750
Total Revenue	92,250	144,000	140,250	156,000	153,375
Total Costs	219,500	179,000	111,500	152,000	145,250
Profit	-127,250	-35,000	28,750	4,000	8,125

NOTE: All consumption data reported in m^3/month