Economics for Wholesale Electricity Markets

Dr. William Shobe
Existing Plant Decision-making

Module 4
Objective

• With cost curves in hand, we explore
  • When it is advantageous to run an existing plant
  • How plants make a profit
  • When would you offer to sell additional power?
  • What does this tell us about the order in which we should choose to use existing plants?
When to run an existing plant

• Suppose you own a plant like Plant 1 in our earlier example
• Key facts:
  • Fixed monthly payment: $2,128,968
  • Marginal cost is the fuel cost per MWh: $22.5
  • LCOE (long run average total cost): $29.9
  • LCOE based on an average capacity factor of 80%
  • Plant is not under a long-term contract to a discom - merchant

• Question: What do you make each month if you do not run the plant?
An offer

• You get an offer from a discom to buy 50% of the capacity of your plant

• At 50% capacity (250 MW),
  • Your average total cost per MWh is $34.3
  • Average fixed cost is $11.8
  • Marginal cost is $22.5

• What is the minimum price you would take?
Cost profile: Baseload

- MC (AVC)
- ATC
- Dollars per mWh
- Capacity factor
- MC (AVC)
<table>
<thead>
<tr>
<th>Price</th>
<th>Net position</th>
<th>Relative to not running the plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Don't run plant)</td>
<td>($2,128,968)</td>
<td></td>
</tr>
<tr>
<td>$20.00</td>
<td>($2,578,968)</td>
<td>($450,000)</td>
</tr>
<tr>
<td>$22.50</td>
<td>($2,128,968)</td>
<td>$0</td>
</tr>
<tr>
<td>$25.00</td>
<td>($1,678,968)</td>
<td>$450,000</td>
</tr>
<tr>
<td>$34.33</td>
<td>$0</td>
<td>$2,128,968</td>
</tr>
<tr>
<td>$35.00</td>
<td>$121,032</td>
<td>$2,250,000</td>
</tr>
</tbody>
</table>
Conclusion

• You should run the plant whenever the price is greater than average variable cost
  • At any price above average variable cost (here, $22.50), running the plant increases earnings
  • Even if you can’t make a profit, you are losing less money.
  • At less than $22.50, you should not run the plant.
• Note: in this example AVC = MC.
How do plants make a profit?

• For an existing plant, the plant makes a ‘profit’ when price is at or above ATC for a given capacity factor.
  • A price equal to ATC implies that investors are earning a ‘normal rate of return’ on their investment.
  • A price above ATC implies that the plant is earning “scarcity rents” or “extra-normal profits”
    • This is the extra profit from running a low cost plant at time when prices are high.
Cost profile: Baseload

- ATC
- MC (AVC)

Capacity factor vs. Cost profile: Baseload

- Dollars per mWh
- Capacity factor

Plot showing the relationship between capacity factor and cost profile for a baseload scenario.
Conclusion

• A plant makes a normal rate of return (economists call this zero “economic” profit) when price = ATC
  • Price > ATC implies economic profit (scarcity rents)
  • Price < AVC implies increasing losses (so shut down)
  • Price in between AVC and ATC implies running the plant to decrease losses due to fixed costs
• Running when price > AVC recovers as much of fixed costs as possible
Changing prices

• As prices change during a day, a month or a year, then a plant will have periods with extra profits and periods with losses.
  • As long as this averages out to at least average variable costs, the plant should be made available to run.
  • Since you are covering your variable costs, there are net earnings that can be applied to paying some fixed costs.
  • If price stays below AVC, the plant should be taken out of service, to minimize losses.
When to offer to sell additional power

• Up to now, we have discussed when to operate a plant and how much money it will bring in.

• Another (and related) question: when should I choose to sell an additional MWh from my plant?

• Easy answer: whenever it makes me more money than it costs me
Marginal cost review

• Marginal cost is the cost to you of producing an additional unit of output, here, one MWh.
  • This includes fuel, staff, wear and tear, etc.; any consequences of generating one additional MWh
  • In my examples so far, I have assumed (for simplicity) that MC is constant, but for most plants, MC probably falls at first, is flat for a range, and then rises at very high capacity factors.
  • Either way, the definition is the same.
Does additional output make money?

• If price > MC, then selling one additional unit makes me more money than it costs me.
  • So, whenever price > MC, I should expand production
  • When price < MC, production should be reduced
  • Where MC is constant, p > MC means production should expand to the lowest point on the ATC curve.
    • If MC starts to rise at high capacity factors, then the lowest ATC will be at less than 100% capacity.
Which plants should be run?

- Let’s suppose that we need to bring some additional capacity online for the next hour.
- For this example, each of our three plants, baseload, peaker and solar have 100 MW available.
  - And demand reduction is available as well.
- Which plant(s) should we use?
- *First, what would be the long-run contract price for each source? (Hint: LCOE)*
Levelized cost of energy

Levelized cost of energy (long-term contract price)
Which plant should we run?

• Suppose you owned these three plants.
• You need an additional 100 MWh.
• Which plant should you run in order to make the most money?

• To answer this, let’s look at the “supply stack”.
The supply stack

Marginal cost and LCOE of capacity

- Solar
- Baseload
- Peaker
- Demand reduction

MegaWatt hours

Dollars
Cost of incremental supply

• What does it cost you to produce the extra 100 MWh?
  • Solar: $?
  • Baseload:
  • Peaker:
  • DR:
Cost of incremental supply

• What does it cost you to produce the extra 100 MWh?
  • Solar: $0
  • Baseload: $?
  • Peaker:
  • DR:
Cost of incremental supply

• What does it cost you to produce the extra 100 MWh?
  • Solar: $0
  • Baseload: $22.50 * 100 = $2,250
  • Peaker: $?
  • DR:
Cost of incremental supply

• What does it cost you to produce the extra 100 MWh?
  • Solar: $0
  • Baseload: $22.50 * 100 = $2,250
  • Peaker: $37.50 * 100 = $3,750
  • DR:
Cost of incremental supply

• What does it cost you to produce the extra 100 MWh?
  • Solar: $0
  • Baseload: $22.50 * 100 = $2,250
  • Peaker: $37.50 * 100 = $3,750
  • DR: $80.00 * 100 = $8,000

• What if you had used LCOE as your guide?
  • Baseload, then Solar, then Peaker, then DR
  • You would have spent $2,250 instead of $0
Let’s talk price

• Now suppose that you are offered $20 per MWh for additional power.
  • What should you do?
The supply stack

Marginal cost and LCOE of capacity

MegaWatt hours
Merit order

• Consider different levels of demand that might occur over the year.
  • Responding to demand in marginal cost order is the most profitable and cost-effective.

• Low marginal cost plants have greater merit!
Violations of merit order

• Common reasons for violations of merit order:
  • Transmission constraints
  • Regional/state dispatch
  • Operational flexibility
    • Minimum cf for fossil and nuclear plants
    • Slow ramp rate
The supply stack

Marginal cost and LCOE of capacity

MegaWatt hours

Dollars
Conclusion

• If they were your plants, you would make more money by operating them in order of increasing MC (aka: merit order)

• If you used LCOE, you would make much less money.

• For a given price, you maximize profit if you run any plant for which price > MC.
  • This makes more money than if you use LCOE (or long-term contract price).
Conclusion

• Costs of generation are minimized when assets are run according to marginal cost.

• A plant may operate even when it is losing money.
  • As long as it is covering variable costs

• Key Point: Even if a plant operates at a loss at times, it may be profitable on average so long as there are periods when it can earn scarcity rents