Economics for Wholesale Electricity Markets

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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?

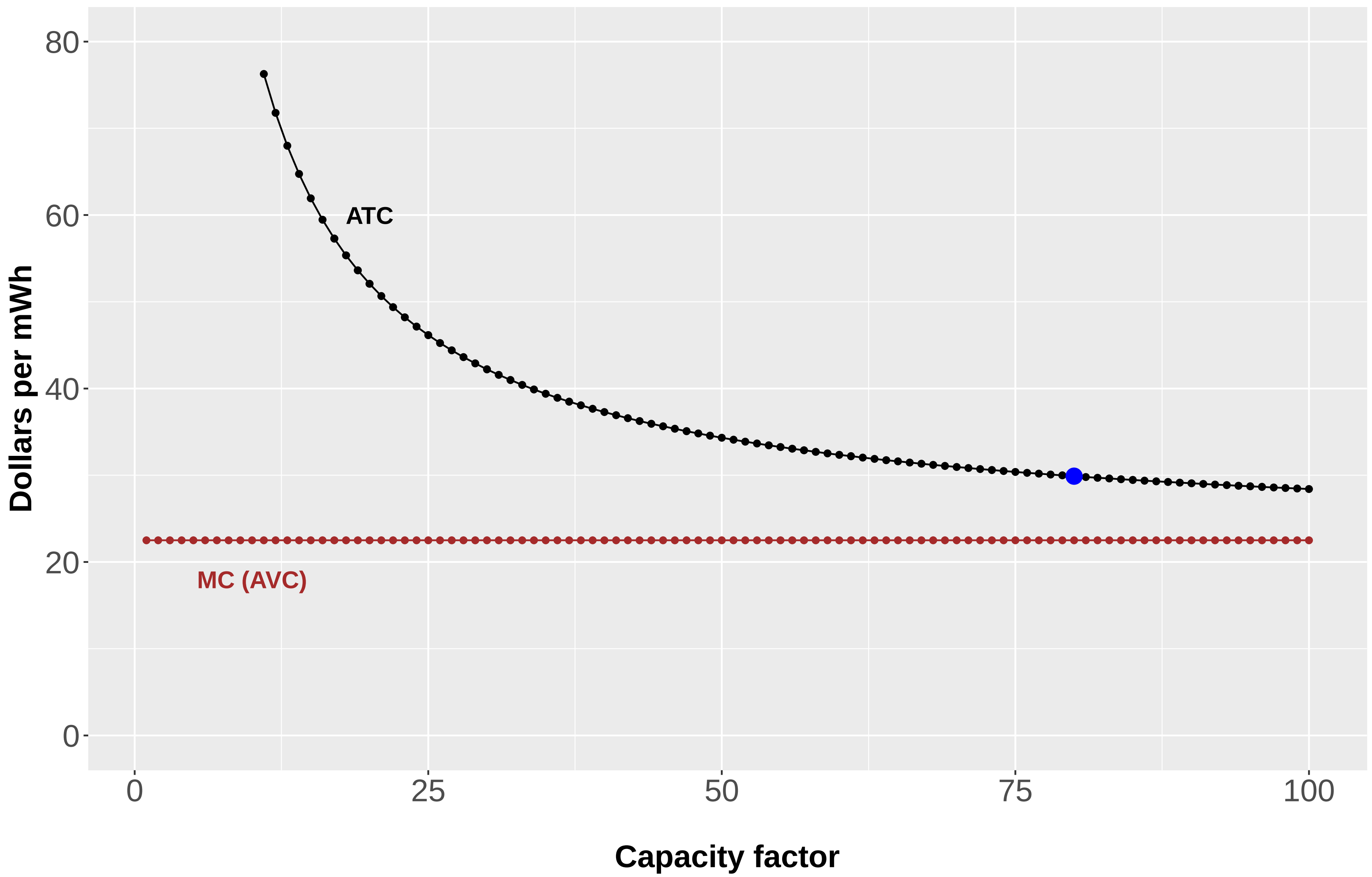
When to run an existing plant

- 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



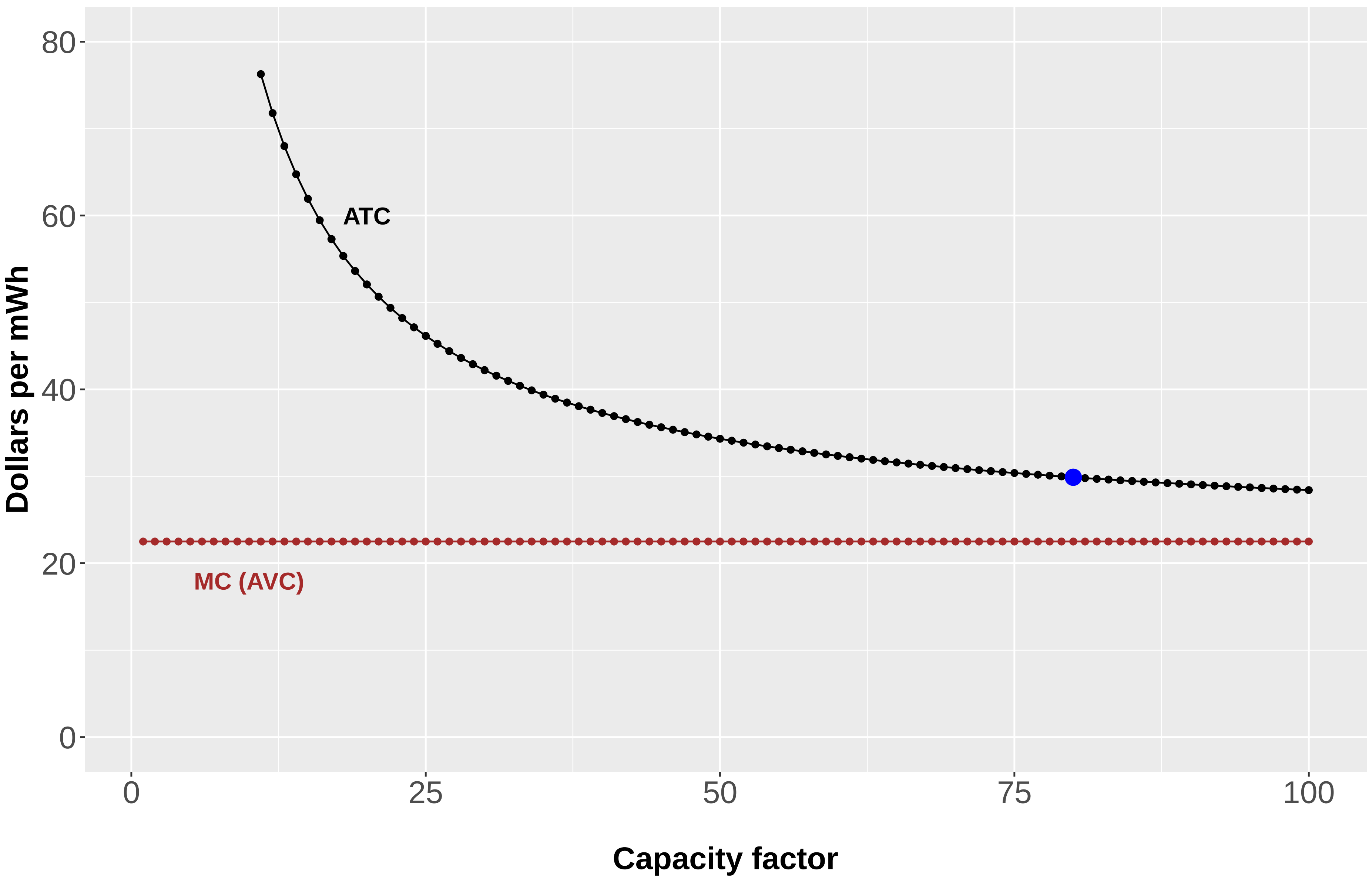
The bottom line

Price	Net position	Relative to not running the plant
(Don't run plant)	($2,128,968)	
$20.00	($2,578,968)	($450,000)
$22.50	($2,128,968)	$0
$25.00	($1,678,968)	$450,000
$34.33	$0	$2,128,968
$35.00	$121,032	$2,250,000

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.

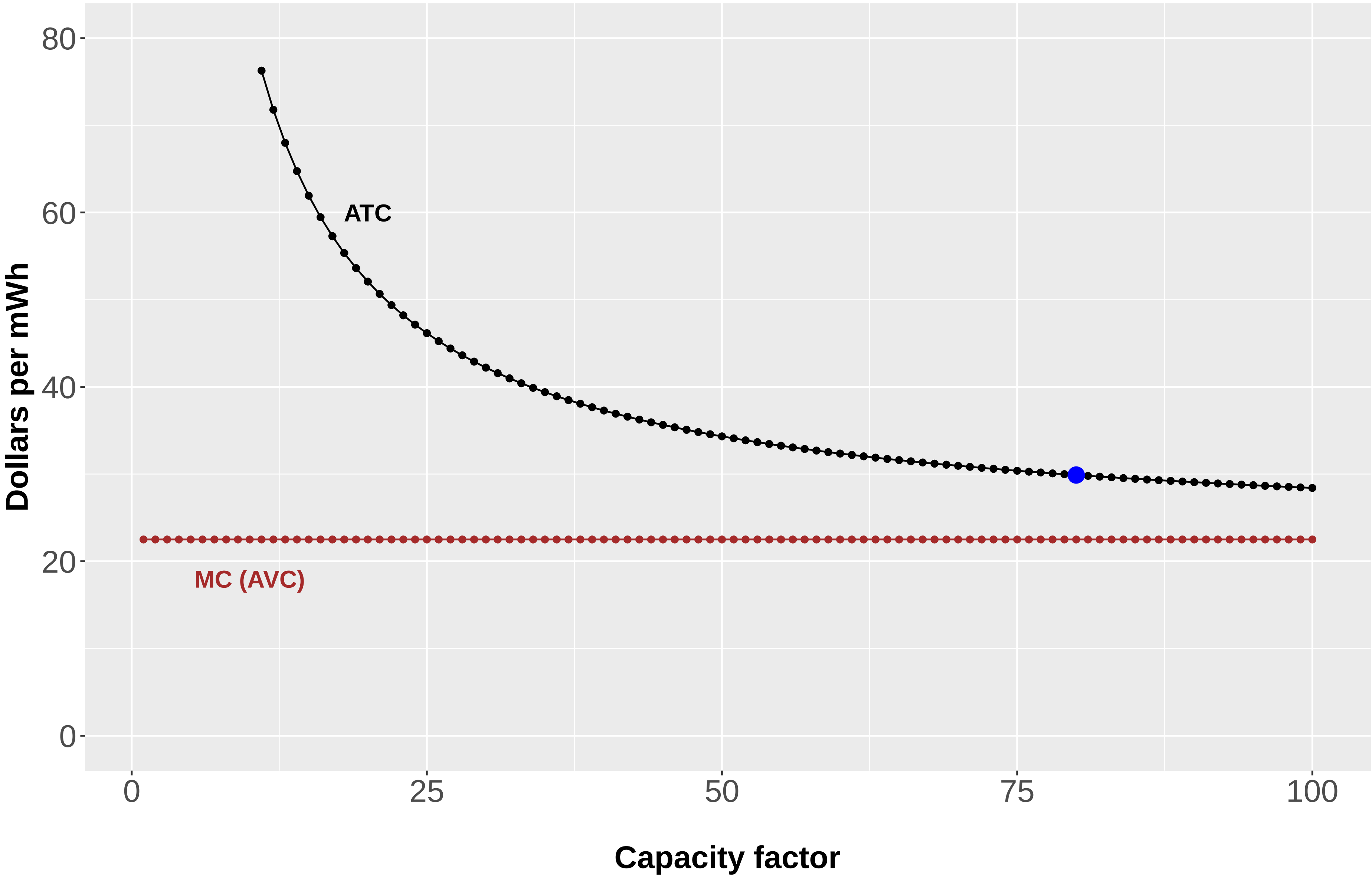
Cost profile: Baseload



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



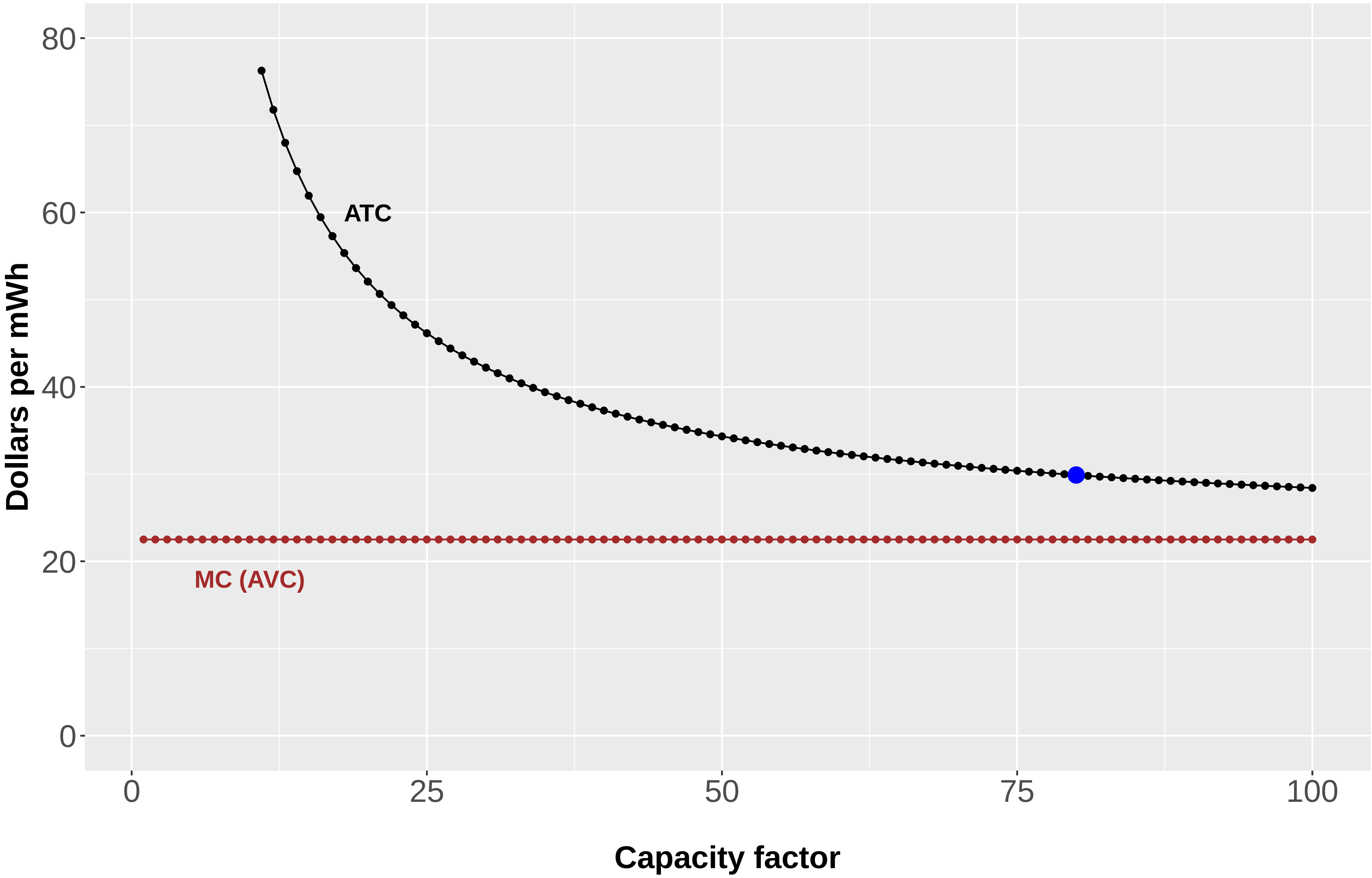
Conclusion

- 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.

Cost profile: Baseload



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.

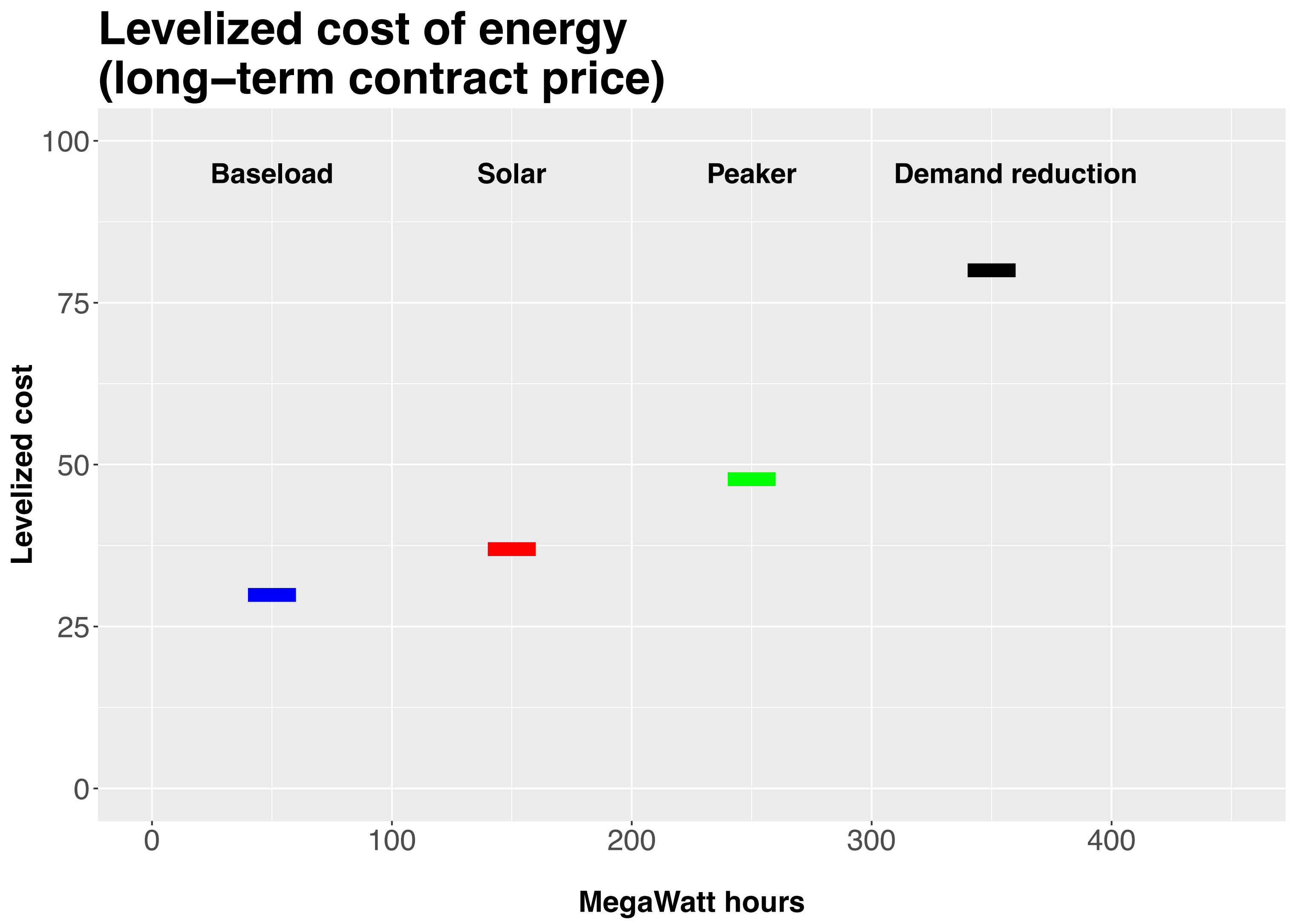
Does additional output make money?

- 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

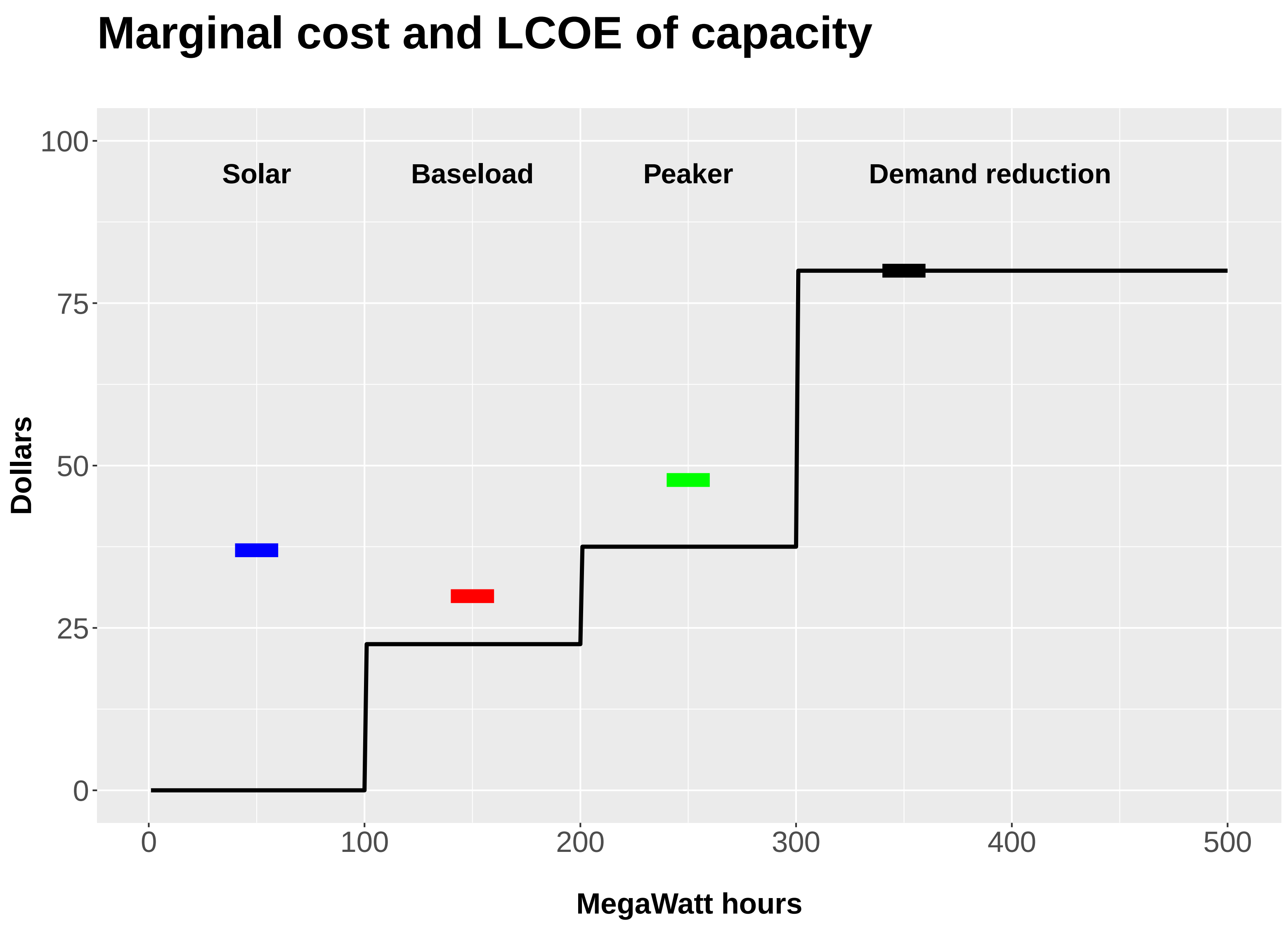


Which plant should we run?

- 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



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:

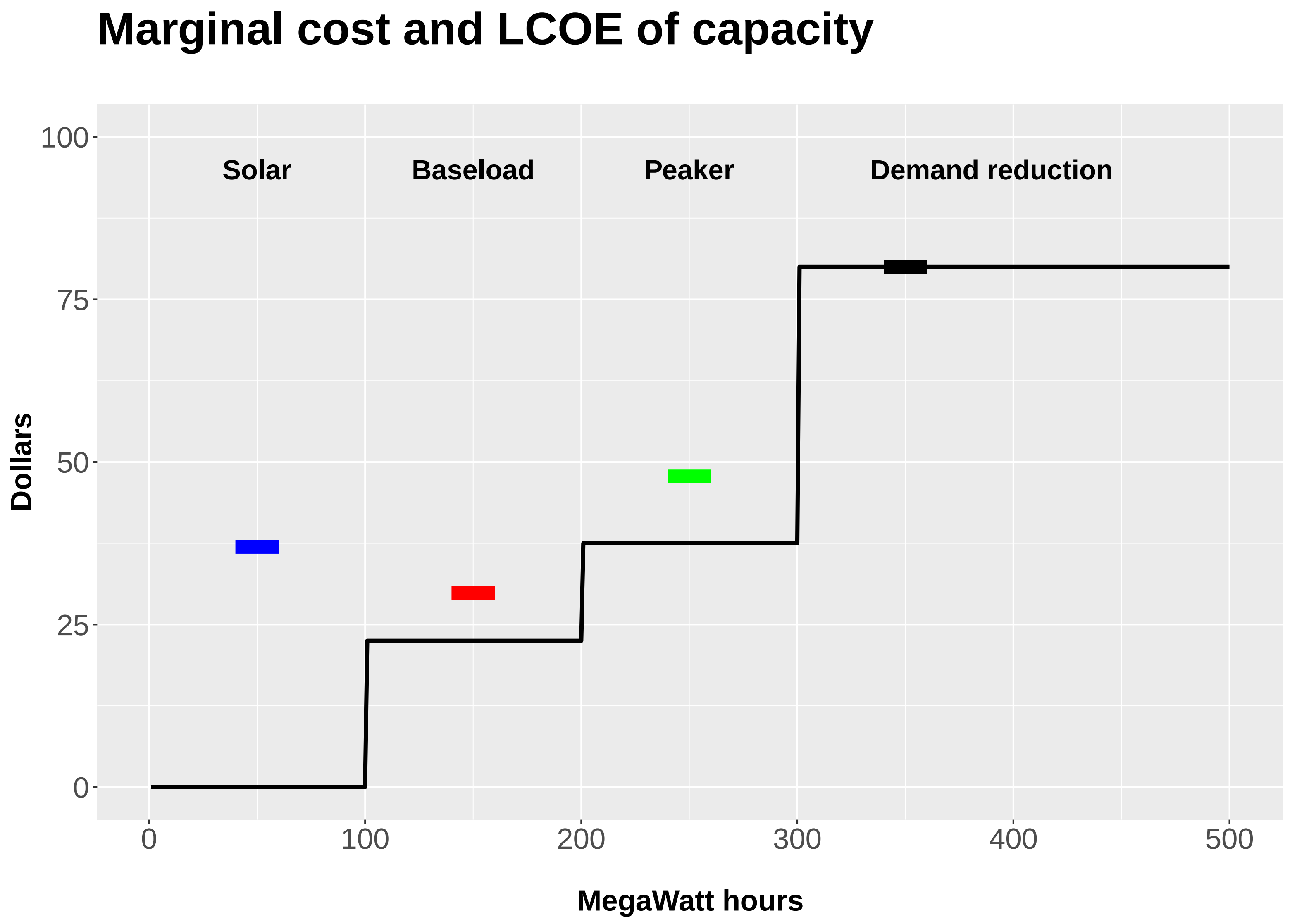
Cost of incremental supply

- 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



Merit order

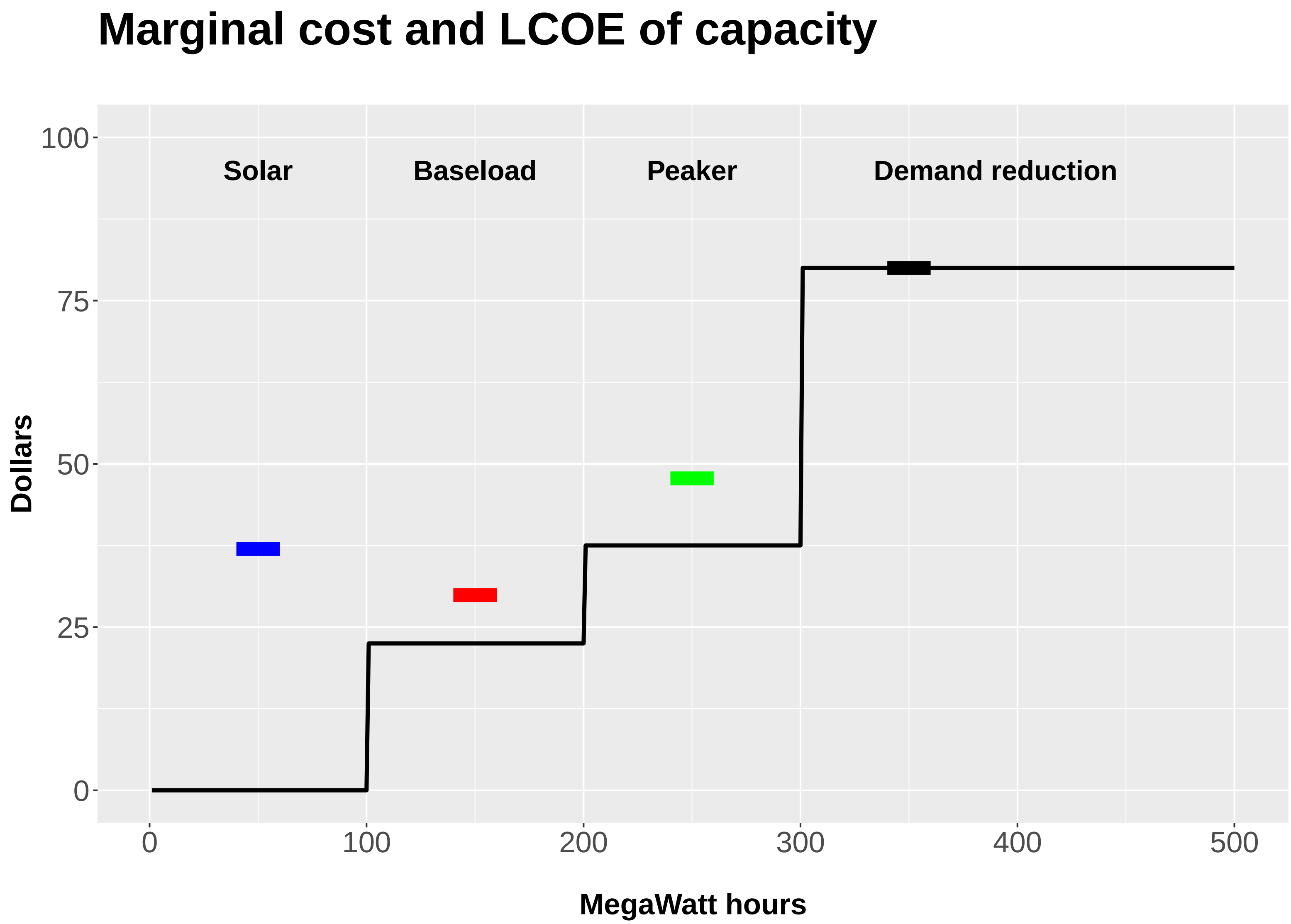
- Consider different levels of demand that might occur over the year.
  - Responding to demand in marginal cost order is the most profitable and cost-effective.
- Low marginal cost plants have greater merit!

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



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