ELECTRICITY AUCTIONS WITH INTEGER DECISIONS

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PLAN

Should we forget short-term prices?

The short-term view on the pricing problem

Long-term considerations

Our proposal

Conclusion

SHOULD WE FORGET SHORT-TERM PRICES?

We began with a day-ahead market, assuming perfect long-term coordination

That might not work, so two solutions

- PPAs – the Latin American solution
- Long-term mechanisms

The second option still requires a short-term price, based on system marginal costs...

... But we do not know how to calculate them

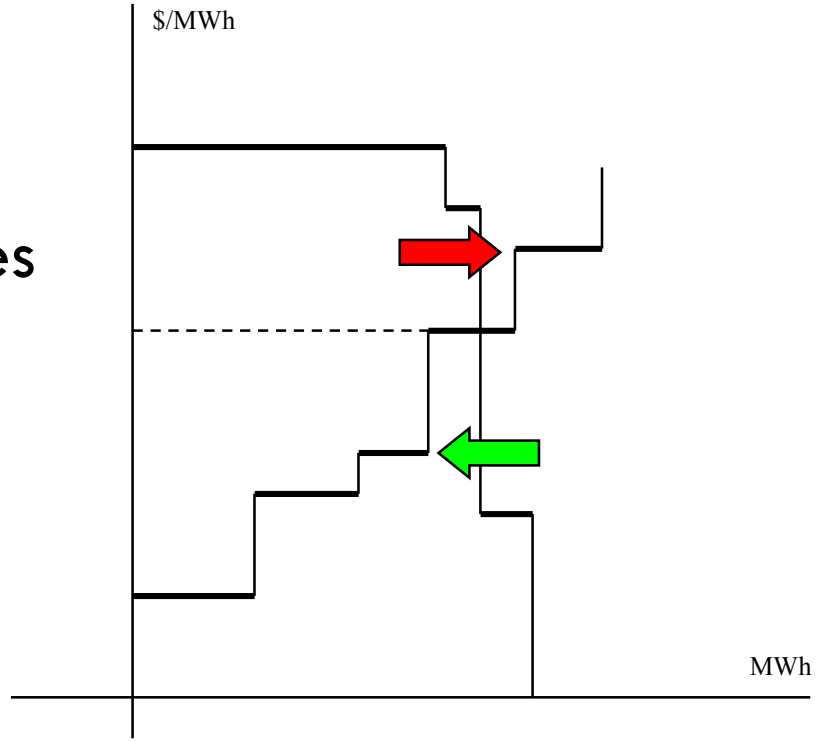
IDEAL WORLD (SHORT-TERM VIEW)

Auction

- Players submit their bids
- Market operator decides prices and quantities

All players should be satisfied

- No accepted bid wants to withdraw
- No rejected bid wants to be dispatched



In the linear case, setting the price equal to the marginal cost satisfies that

INTEGER WORLD (SHORT RUN)

Very simple example:

- One hour
- Three generators
- For each of them: variable cost and discrete cost (e.g. start-up)

PRICE SOLUTION #1: VARIABLE COST OF THE MARGINAL UNIT

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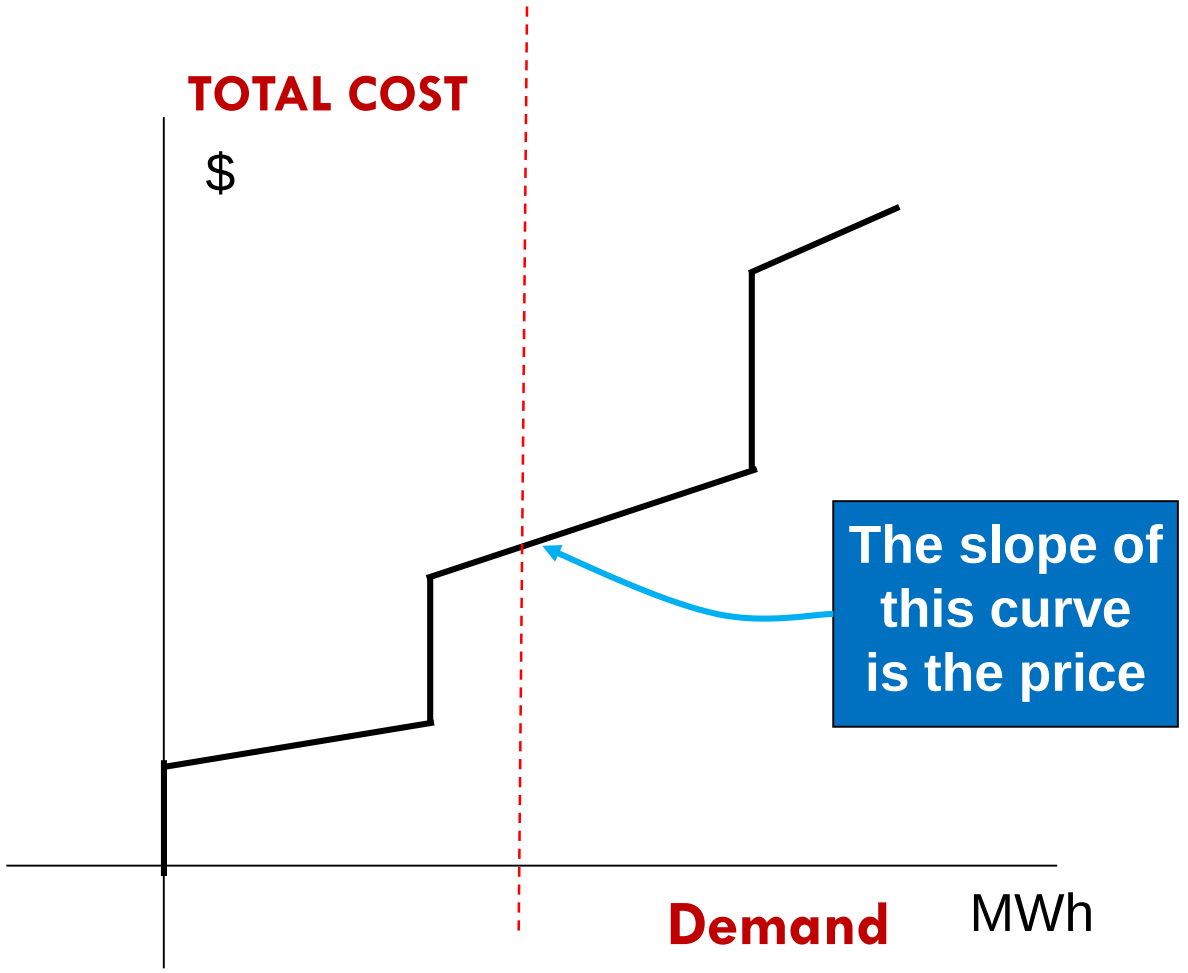
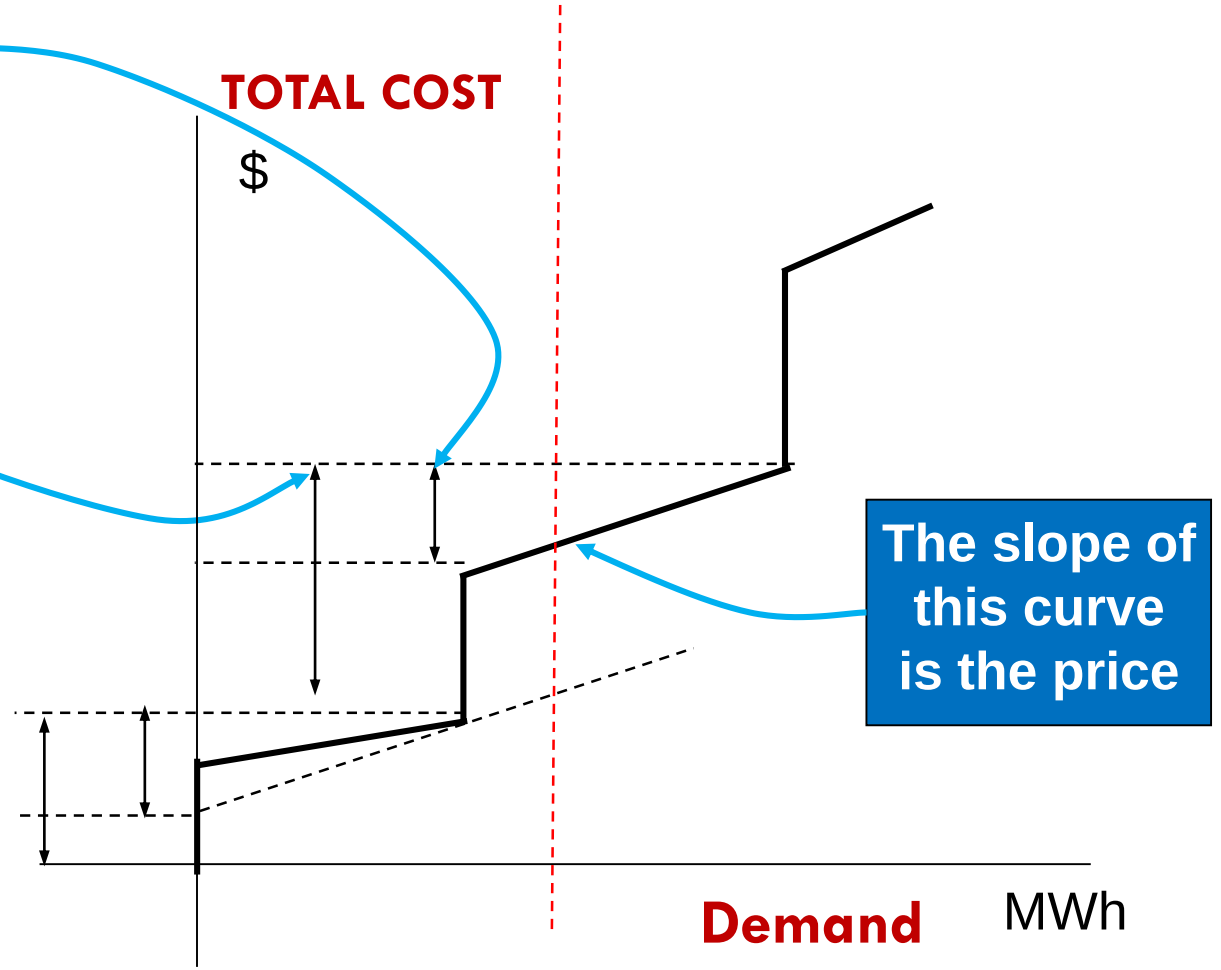


PRICE SOLUTION #1: VARIABLE COST OF THE MARGINAL UNIT

- The second generator receives less than his total cost, and is not willing to produce



PRICE SOLUTION #1: VARIABLE COST OF THE MARGINAL UNIT

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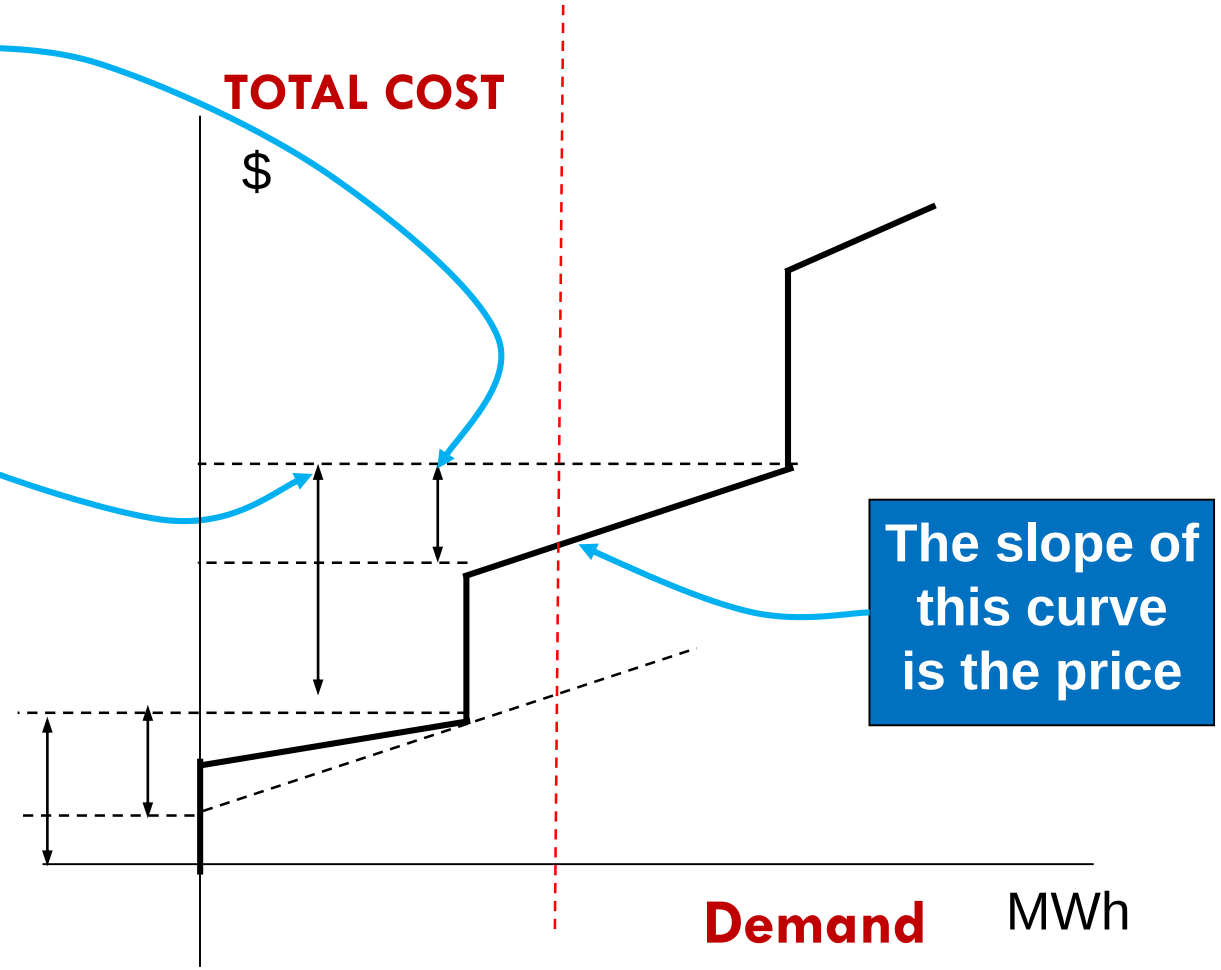
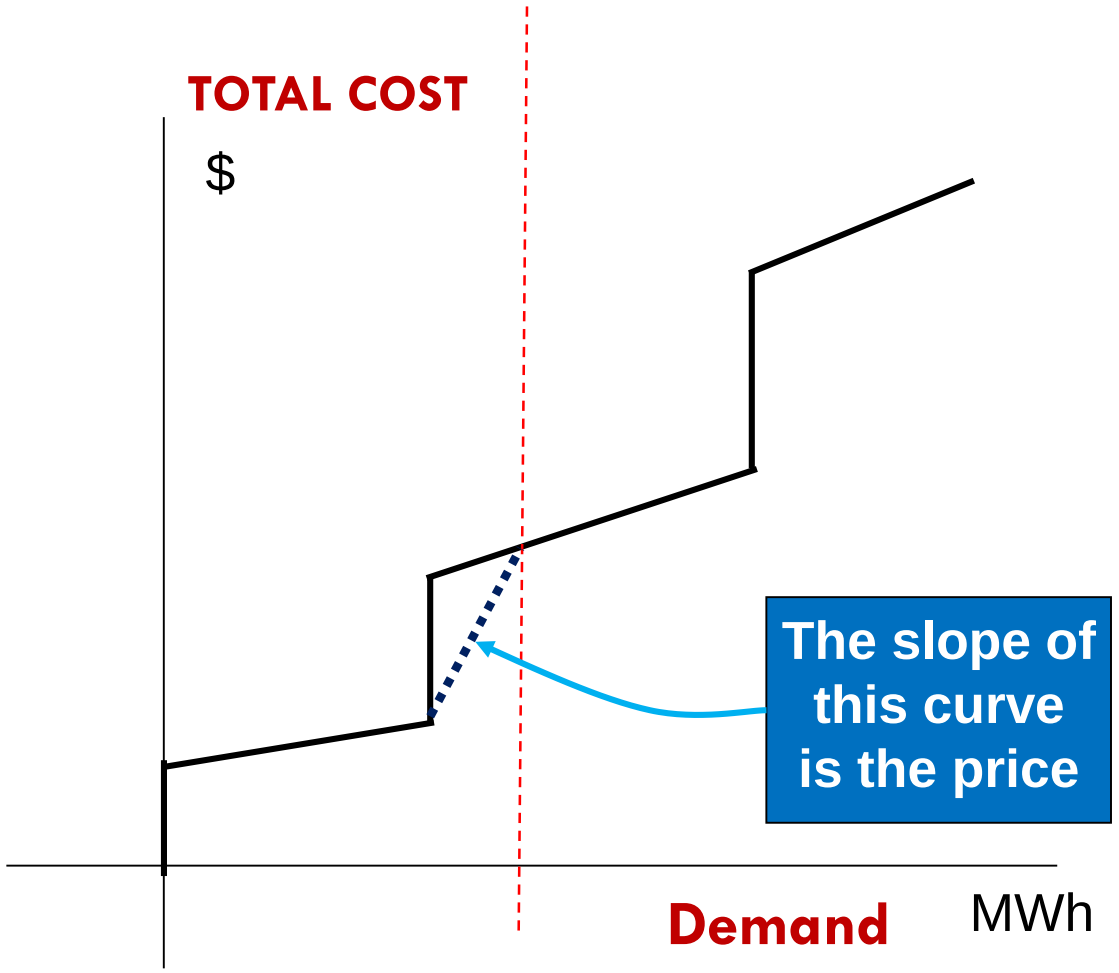
- **Pricing rule not consistent**

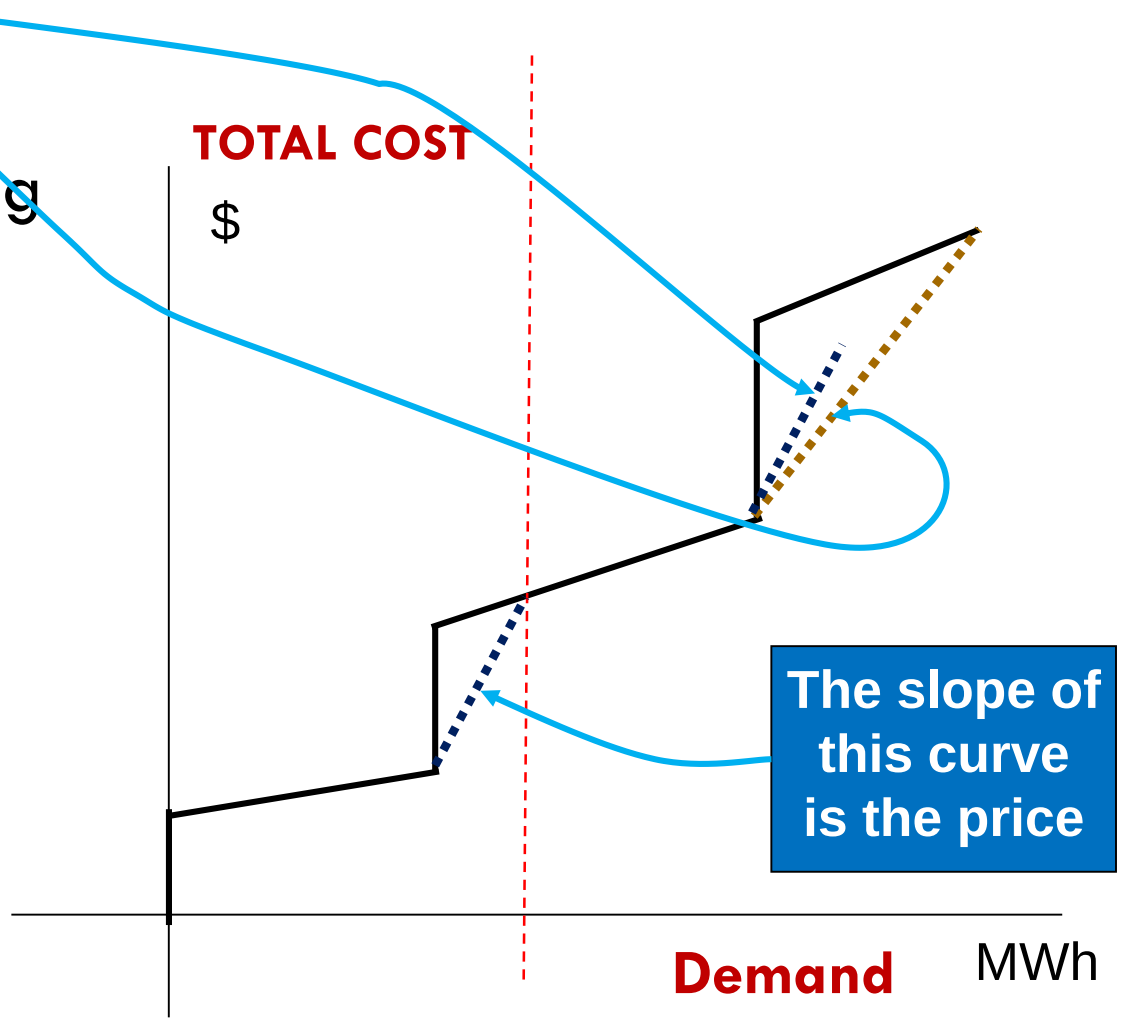


PRICE SOLUTION #2: AVERAGE COST OF THE MARGINAL UNIT



PRICE SOLUTION #2: AVERAGE COST OF THE MARGINAL UNIT

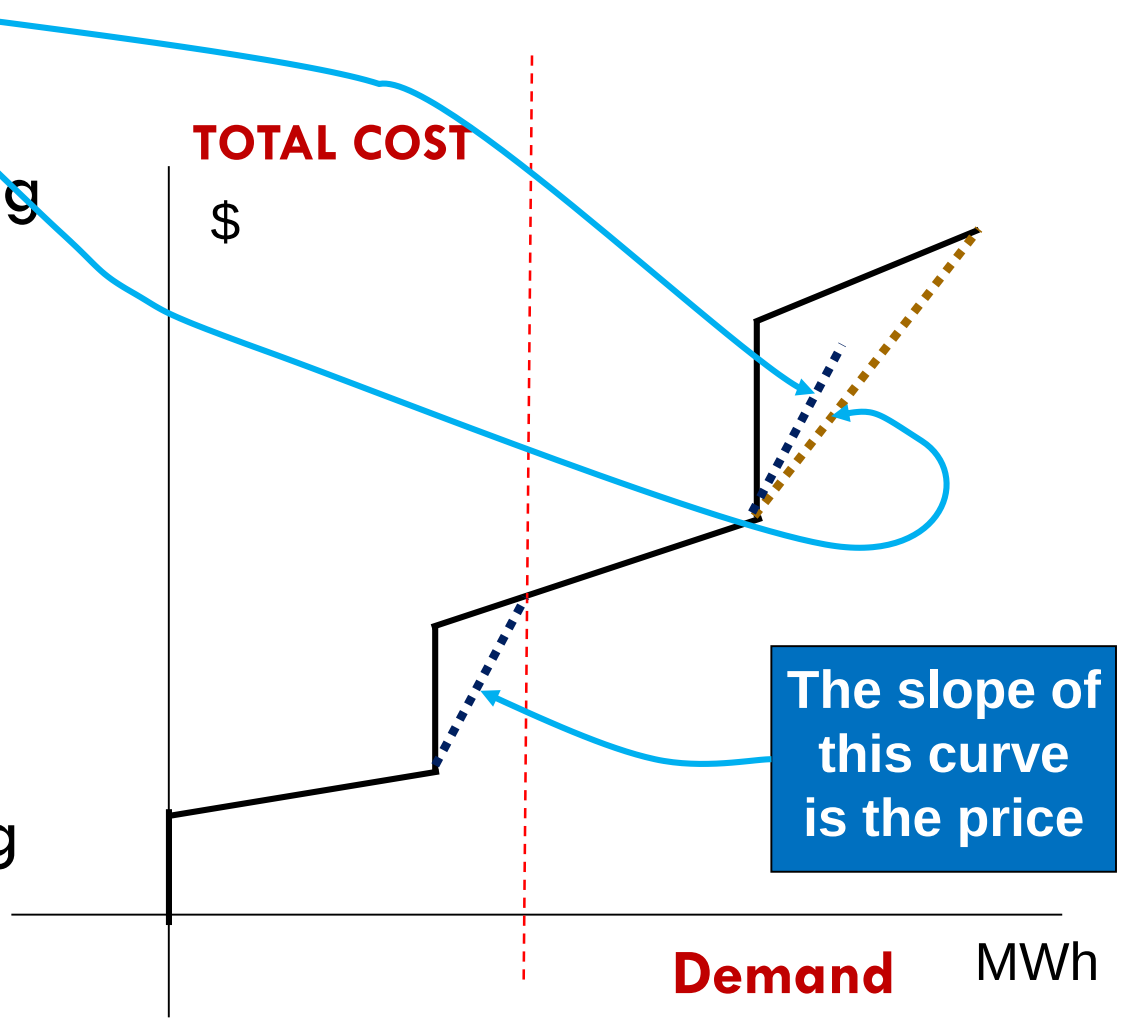
- The price is higher than the costs of the third generator, who is willing to produce



PRICE SOLUTION #2: AVERAGE COST OF THE MARGINAL UNIT

- The price is higher than the costs of the third generator, who is willing to produce

- **Pricing rule not consistent**
- This may be extreme for the cases when the marginal unit is producing very few megawatts



THE NEED FOR SIDE PAYMENTS

In order to solve our problem we need to introduce the concept of side payments

- Common in several complex auctions

So, revenues are divided into

- the marginal price, that all generators receive for each MW produced
- the additional payment, that only some generators receive, and which may be different for each of them

LONG RUN

Are the three options neutral to investment signals?

LONG RUN – ILLUSTRATION

Whether to invest in Tech1 or Tech2 is decided based on:

- $Total\ Cost\ (Tech1) = g_{Tech1}^{max}(5+4) > Total\ Cost(Tech2) = g_{Tech2}^{max}(3+2+2)$
- Tech2 is cheaper than Tech1

	Tech1	Tech2
Variable Cost (€/MW)	5	**3**
Unit Start-up Cost (€/MW)	4	**2**
Unit Investment Cost (€/MW)	**0**	**2**

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Pricing rule #1 (variable cost + side payment)

- $Total\ Cost\ (Tech2) = g^{max}_{Tech2}(3+2+2) > Total\ Income(Tech2) = g^{max}_{Tech2} VarCost(Tech1)$
- The signal sent by the spot market is building Tech1

	Tech1	Tech2
Variable Cost (€/MW)	5	**3**
Unit Start-up Cost (€/MW)	4	**2**
Unit Investment Cost (€/MW)	**0**	**2**

LONG RUN CONSIDERATIONS

The existence of the base-load generator is saving some of the start-up costs of the marginal units

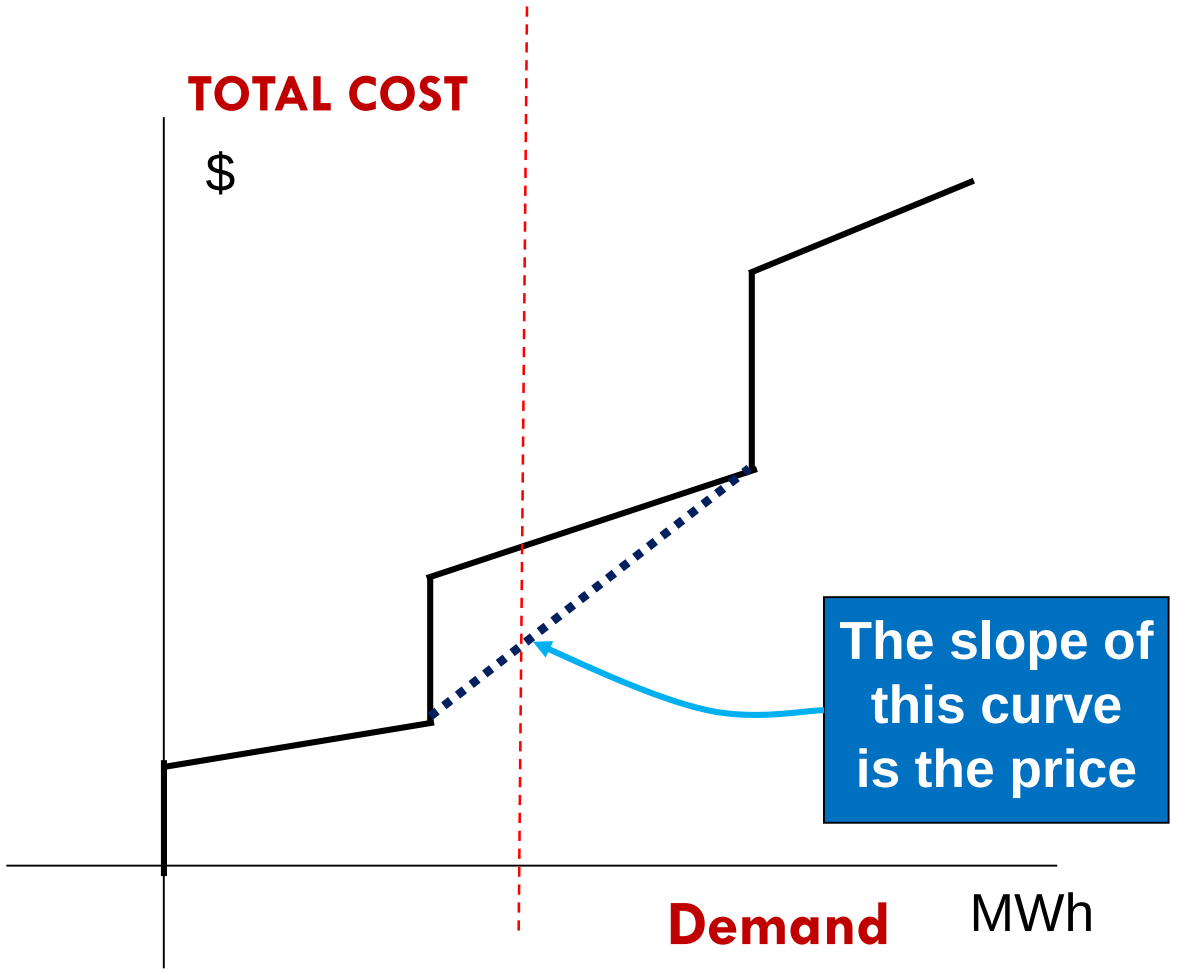
He should be rewarded for that (and so his investment decisions will take that savings into account)

The intuition behind the problem with the previous pricing scheme is that the start-up cost of Tech1 is covered by a side payment, and hence it is not a signal for the investment in Tech2

PRICE SOLUTION #3: AVERAGE COST AT MAXIMUM OUTPUT

For the marginal unit

- Any price higher than its average price at maximum output will make it want to produce at full capacity
- Any price below that will make it want to stop producing
- There is no possible price making it interesting to be marginal



LONG RUN

Our pricing rule

- Gives him more income than in the “only variable cost” case #1
- But less than in the average cost #2.

In the general case, with inter-temporal constraints:

- Price comes from a linear relaxation of the dispatch problem
- …where all costs, including integer ones, are made “small”

CONCLUSION

The pricing rule needs to send long-term signals on start-ups, ramps, etc

Even more in a system where flexibility is taking center stage

- One main concern is including flexibility in long-term mechanisms
- Pricing the short run is a tool that should not be discarded