## Baseline: No Battery

Consider an electricity system with the following capacities and (private) marginal costs:

| Type | Capacity Period 1 | Capacity Period 2 | MC |
|---|---|---|---|
| Solar | 100 | 0 | 0 |
| Wind | 0 | 100 | 0 |
| Coal | 100 | 100 | 50 |
| Gas | 100 | 100 | 100 |

Every plant is small, and there is no market power. But solar plants can only produce during period 1, and wind plants can only produce during period 2.

There are two equally likely, perfectly inelastic, demand scenarios: period 1 demand of 275 MW and period 2 demand of 75 MW.

1. What is the price in each period? How much does each type of plant produce in each period?

**Solution:**

See the "baseline" rows below.

| plant | case | prod | avgP | profit |
|---|---|---|---|---|
| coal | baseline | 100 | 100 | 5000 |
| coal | storage | 150 | 50 | 0 |
| gas | baseline | 75 | 100 | 0 |
| gas | storage | 0 | 0 | 0 |
| solar | baseline | 100 | 100 | 10000 |
| solar | storage | 100 | 50 | 5000 |
| wind | baseline | 75 | 0 | 0 |
| wind | storage | 100 | 50 | 5000 |

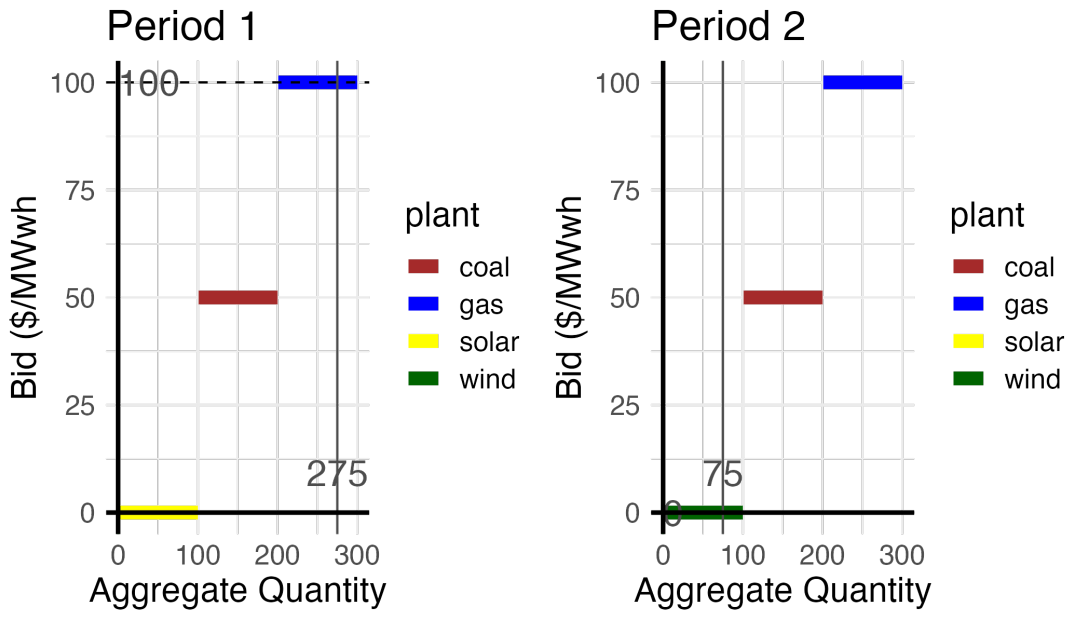


Figure 1: Baseline outcomes

2. How much total operating profit does solar earn in this market?

**Solution:**

10,000. It sells 100 MW at a price of 100 in period 1, and has zero costs.

3. How much total operating profit does wind earn in this market?

**Solution:**

Zero. It sells 75 MW in period 2, but at a price of zero.

### Battery Enters the Market

An independently owned 75 MW battery enters the market. It charges the battery (buys 75 MW of power) in period 2, and then discharges the battery (supplies 75 MW of power) in period 1.

4. What is the price in each period now? How much does each type of plant produce in each period?

**Solution:**

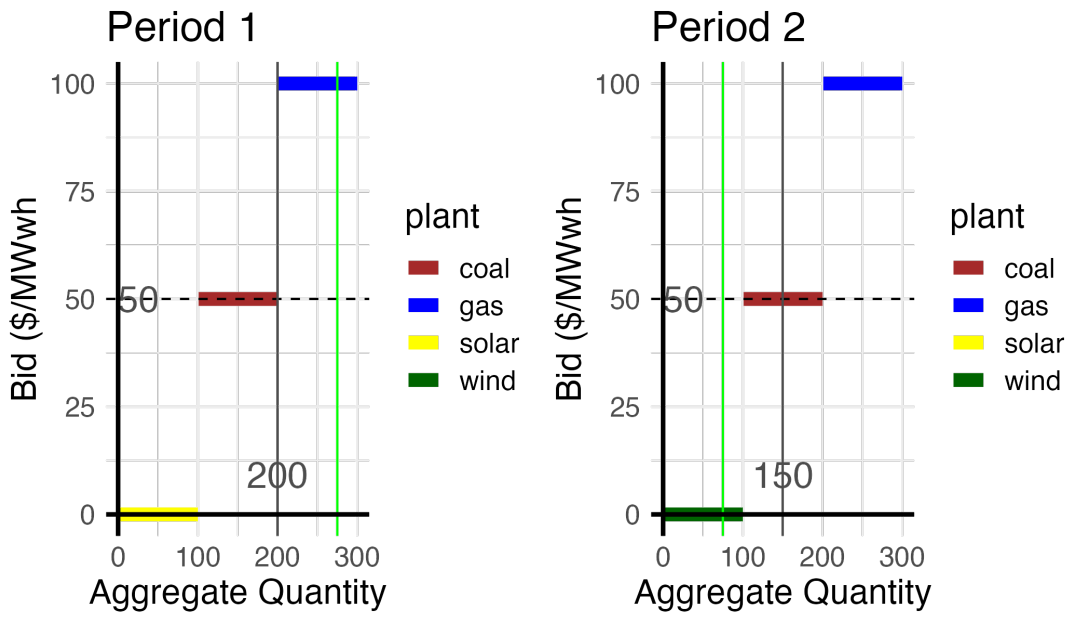


Figure 2: Baseline outcomes

See the "storage" rows below.

| plant | case | prod | avgP | profit |
|---|---|---|---|---|
| coal | baseline | 100 | 100 | 5000 |
| coal | storage | 150 | 50 | 0 |
| gas | baseline | 75 | 100 | 0 |
| gas | storage | 0 | 0 | 0 |
| solar | baseline | 100 | 100 | 10000 |
| solar | storage | 100 | 50 | 5000 |
| wind | baseline | 75 | 0 | 0 |
| wind | storage | 100 | 50 | 5000 |

5. How much total operating profit does the solar earn in this market now? How much does wind earn?

**Solution:**

Solar still sells 100 MW, but at a lower price of 50, for a total of 5,000. Wind sells 100 MW at a price of 50, for a total of 5,000.

6. Consider the impact on consumers. Compared to the world with no batteries, are consumers better off?

**Solution:**

Total expenditure on energy in the baseline is \$275,000. Total with the battery is \$175,000. So consumers are better off.