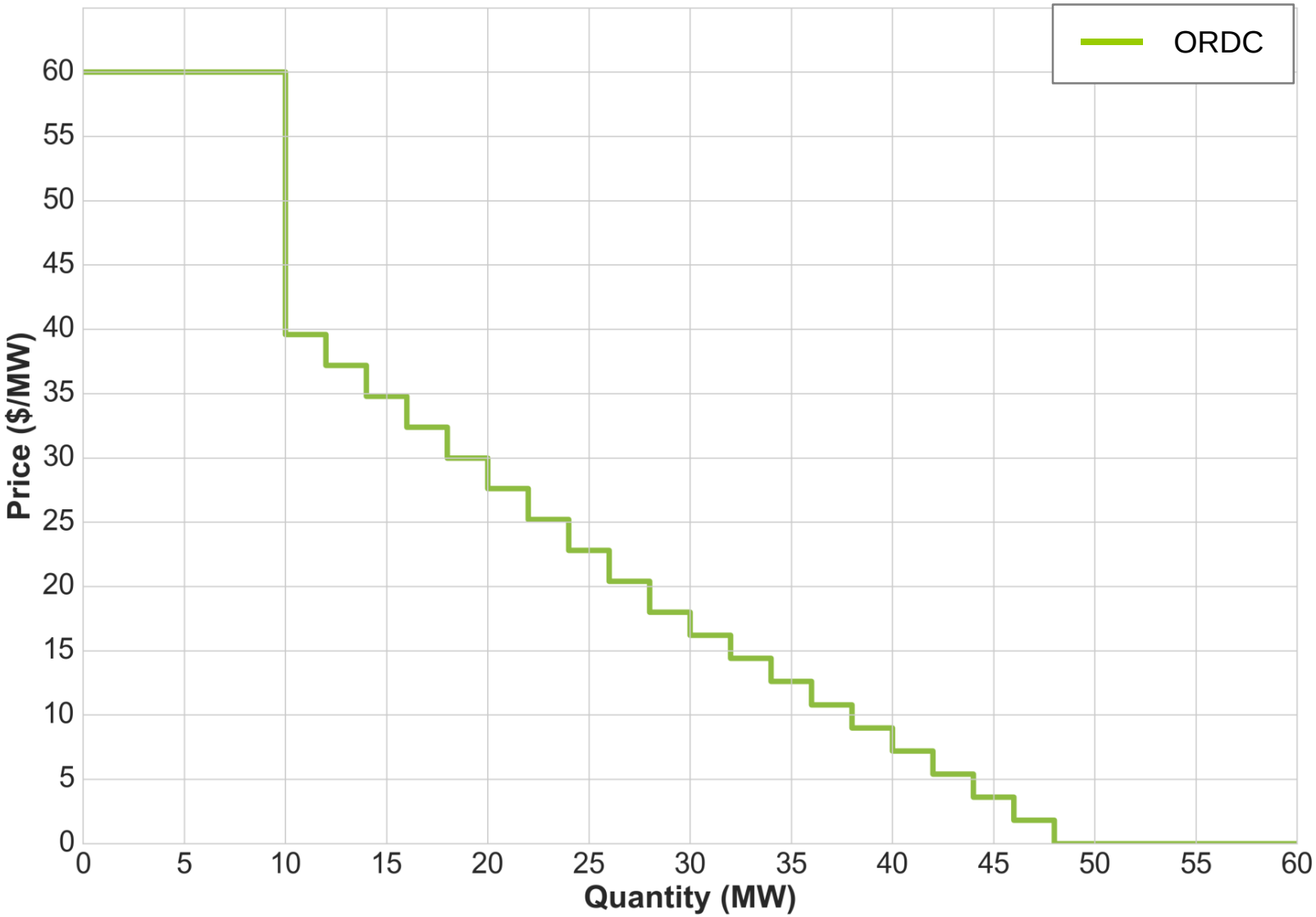
Energy and Reserves Co-Optimization Examples

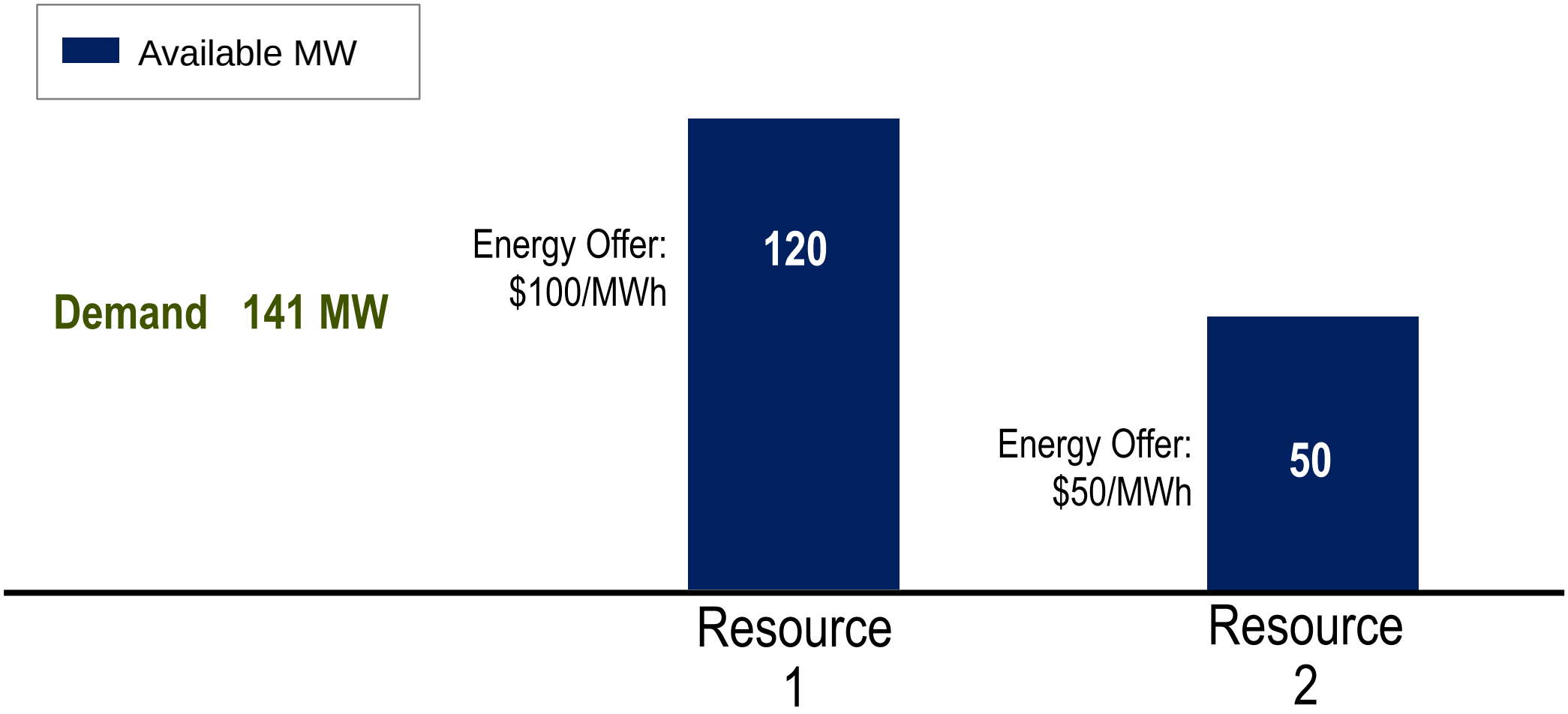
EPFSTF

August 26, 2021

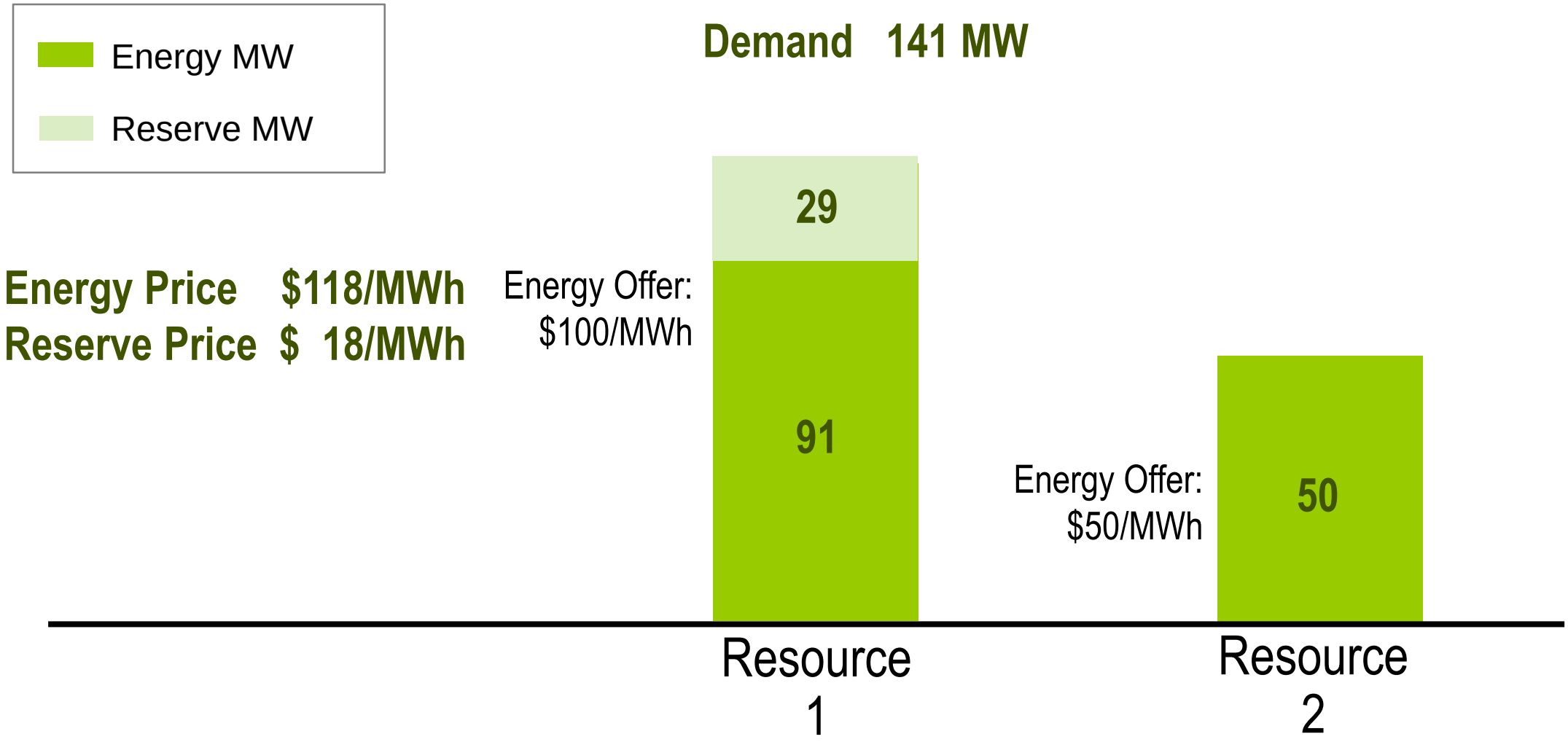
ORDC



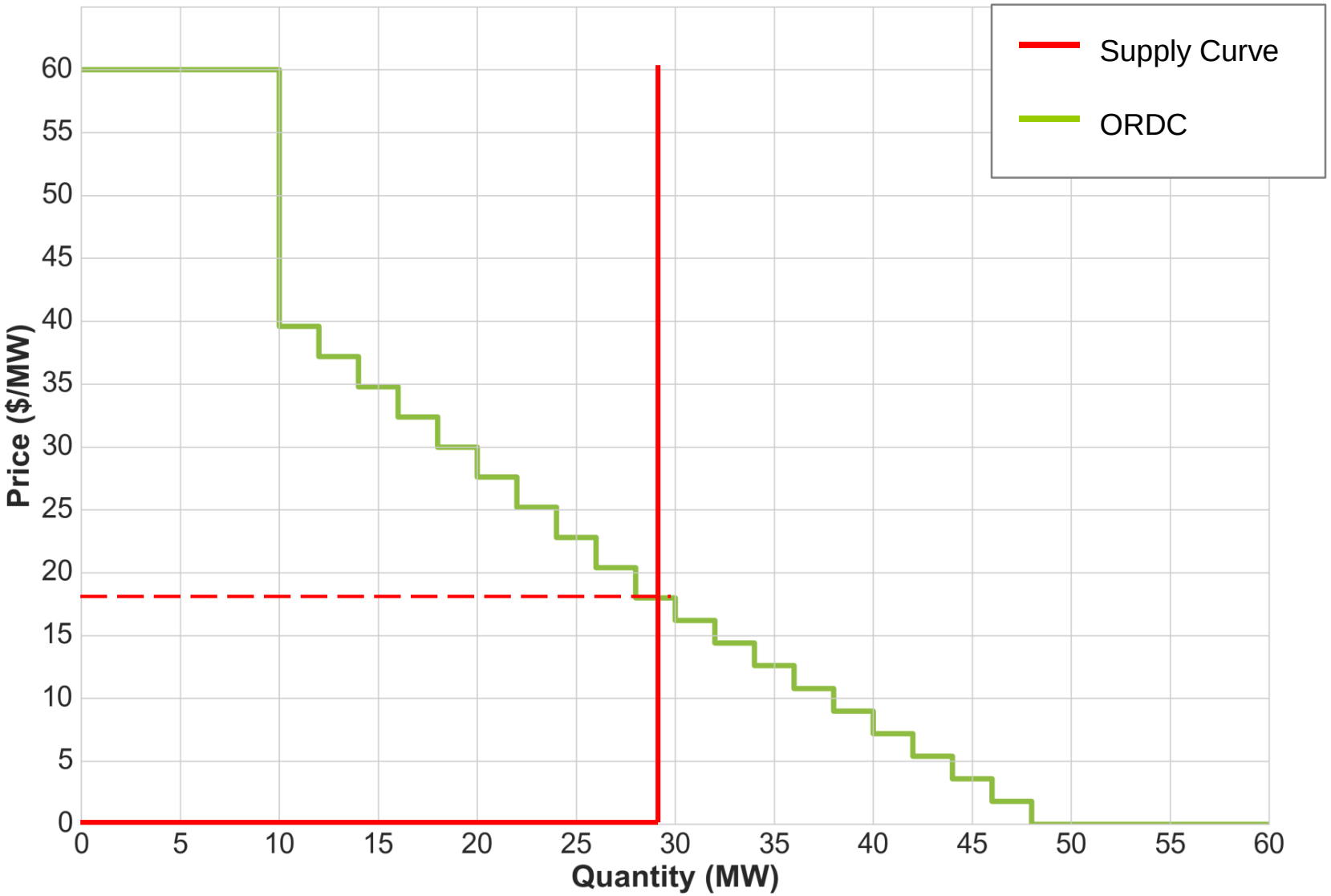
Example #1: Capacity Constrained



Example #1: Results



Example #1: Results - ORDC



Co-Optimizing Energy and Reserves – Example 1

Objective Function = cost to produce energy + cost to produce reserve – willing to pay for reserve

Objective Function = ($50/MW x 50 MW) + ($100/MW x 91 MW) + ($0 MW x 29 MW) - $1158
= **$10,442**

If we need to serve 1 MW of additional energy:

Objective Function (+1MW) = ($50/MW x 50 MW) + ($100/MW x **92 MW)** + ($0WW x **28 MW)** - $1140
= **$10,560**

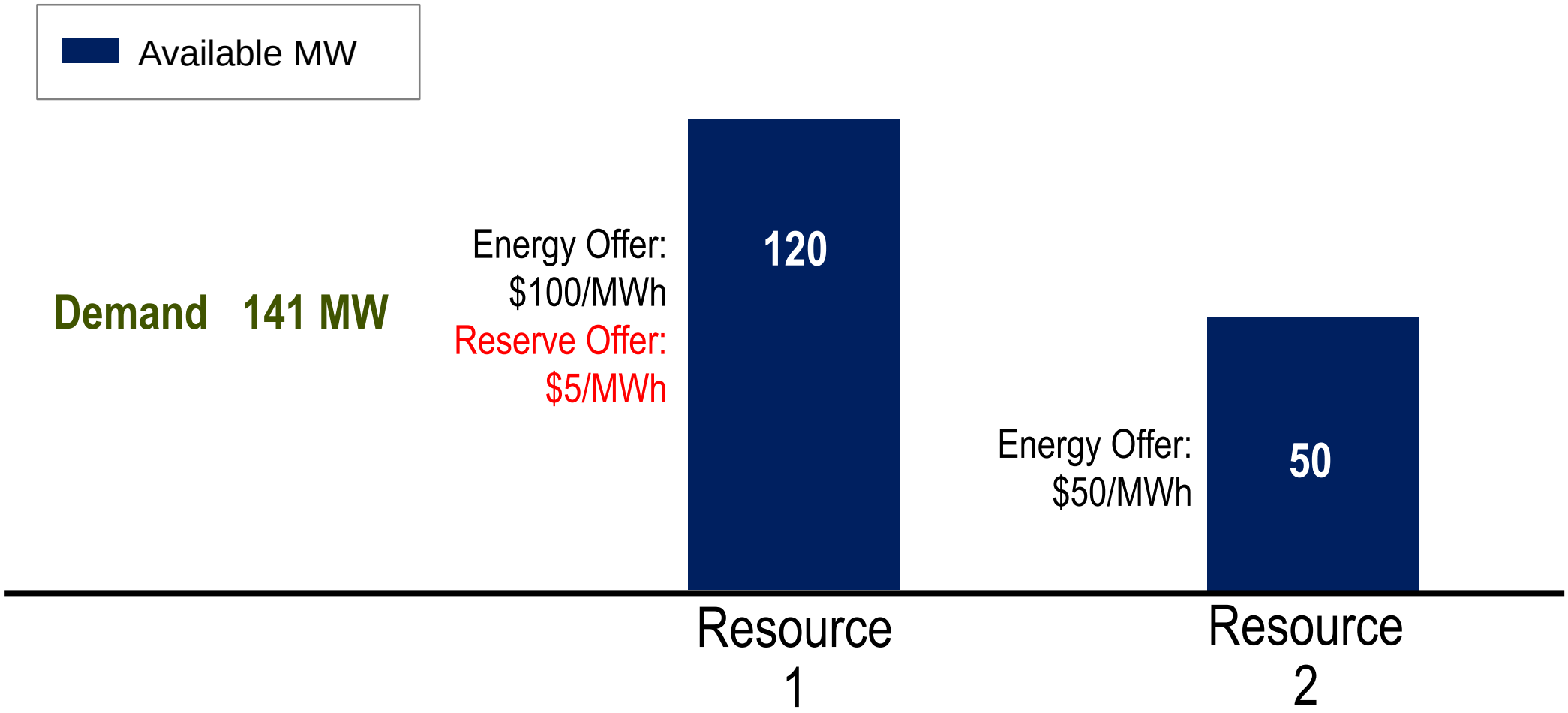
The change in the Objective function to serve 1 MW of additional energy is:

Change in Objective Function = $10,560 – $10,442
= $118

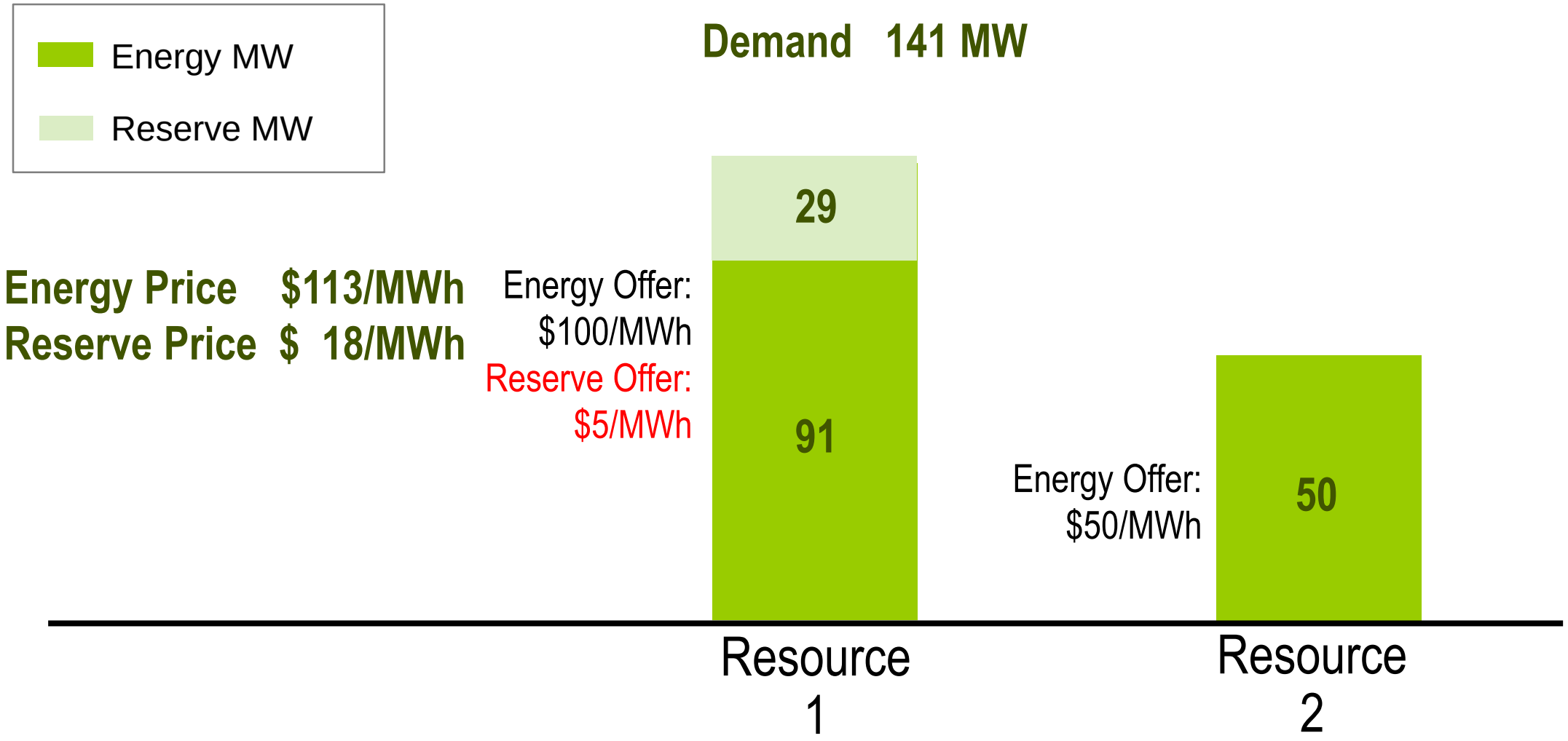
Therefore, the energy clearing price is $118/MWh. Note that, **for this particular example**, the reserve price ($18/MWh) ends up being added to the original energy-only price ($100/MWh)

Resource 1 is indifferent to providing energy or reserves due to the co-optimization of energy and reserves

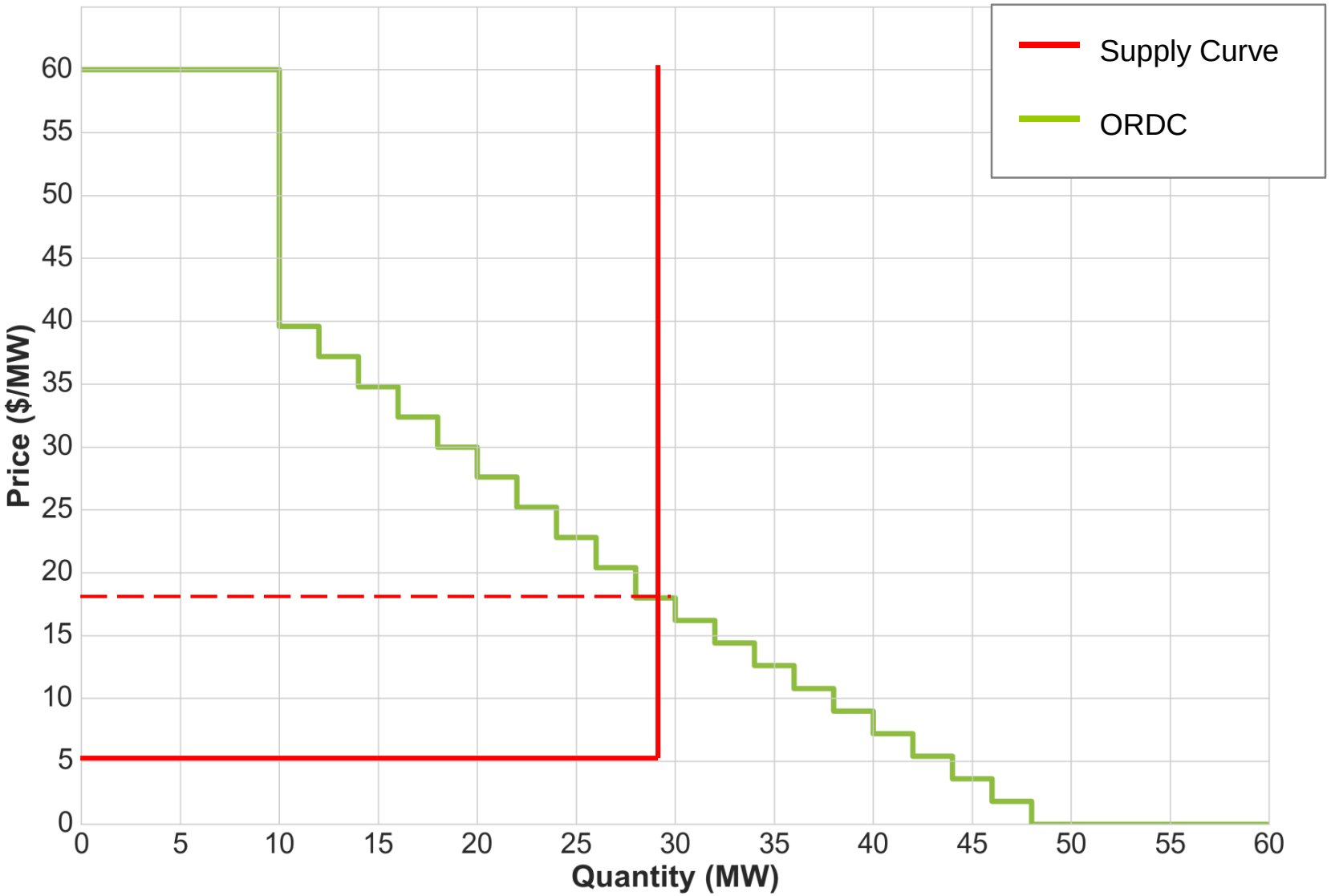
Example #2: Capacity Constrained with Reserve Offer



Example #2: Results



Example #2: Results - ORDC



Co-Optimizing Energy and Reserves – Example 2

Objective Function = cost to produce energy + cost to produce reserve – willing to pay for reserve

Objective Function = ($50/MW x 50 MW) + ($100/MW x 91 MW) + ($5 MW x 29 MW) - $1158
= **$10,587**

If we need to serve 1 MW of additional energy:

Objective Function (+1MW) = ($50/MW x 50 MW) + ($100/MW x **92 MW)** + ($5WW x **28 MW)** - $1140
= **$10,700**

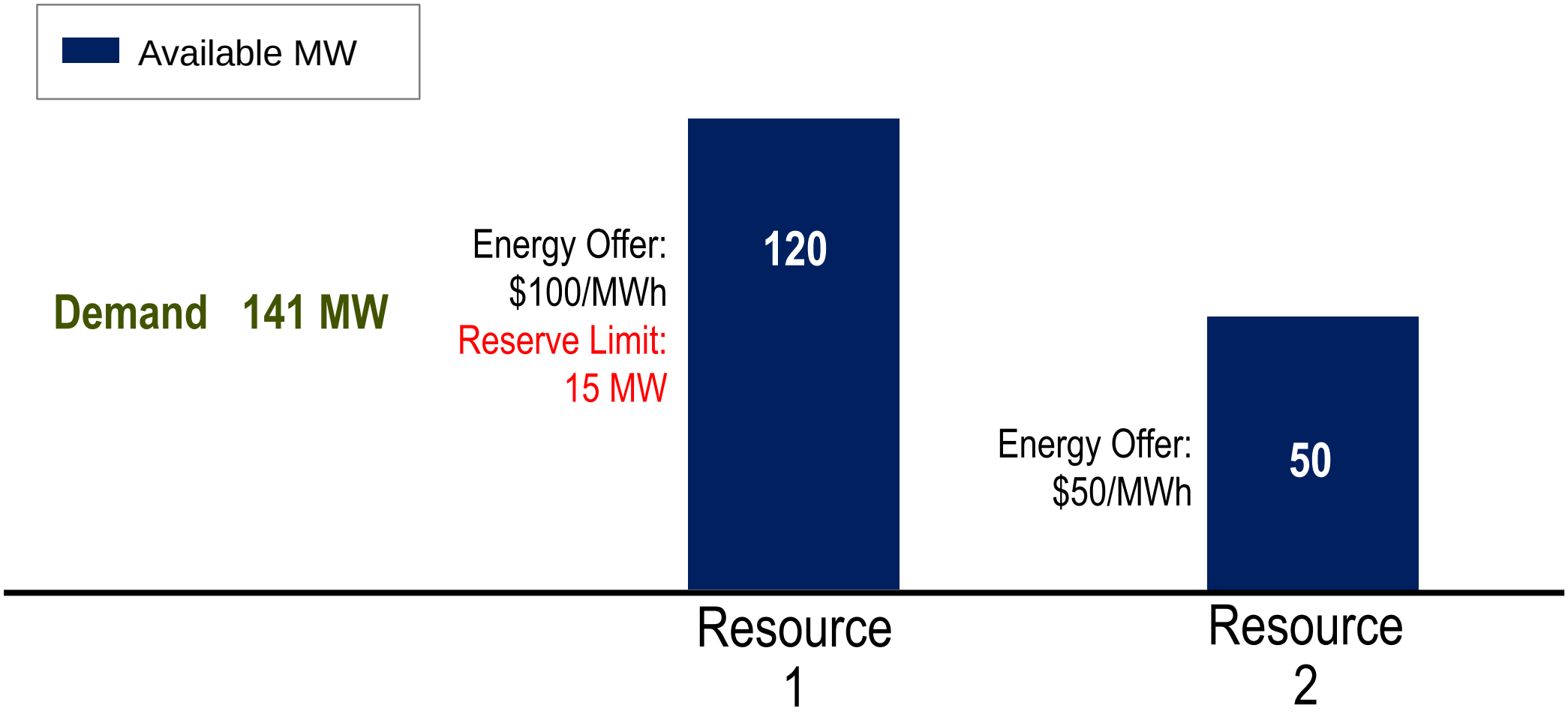
The change in the Objective function to serve 1 MW of additional energy is:

Change in Objective Function = $10,700 – $10,587
= $113

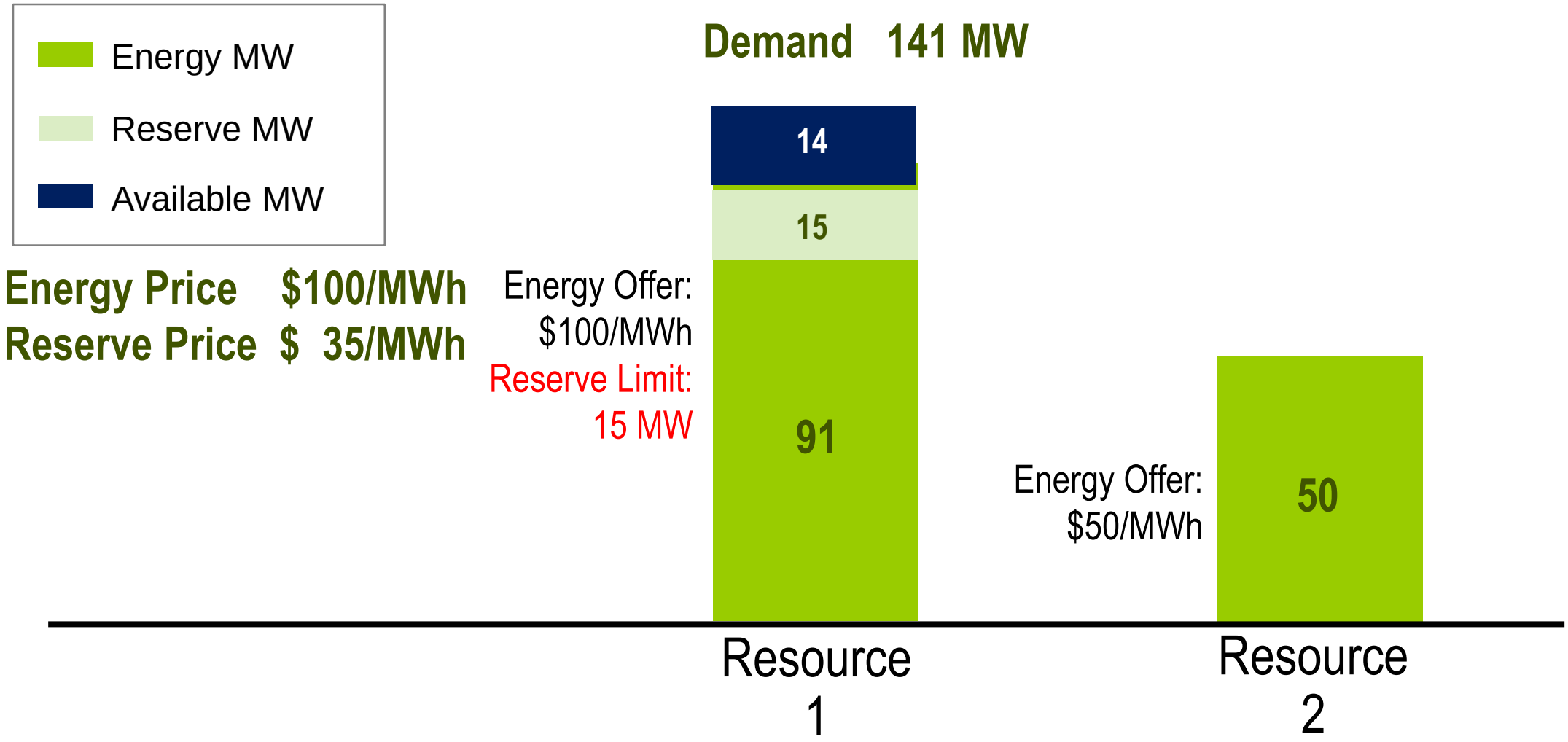
Therefore, the energy clearing price is $113/MWh. Note that, **for this particular example**,
the benefit to the system ($13/MWh) ends up being added to the original energy-only price ($100/MWh)

Resource 1 is indifferent to providing energy or reserves due to the co-optimization of energy and reserve

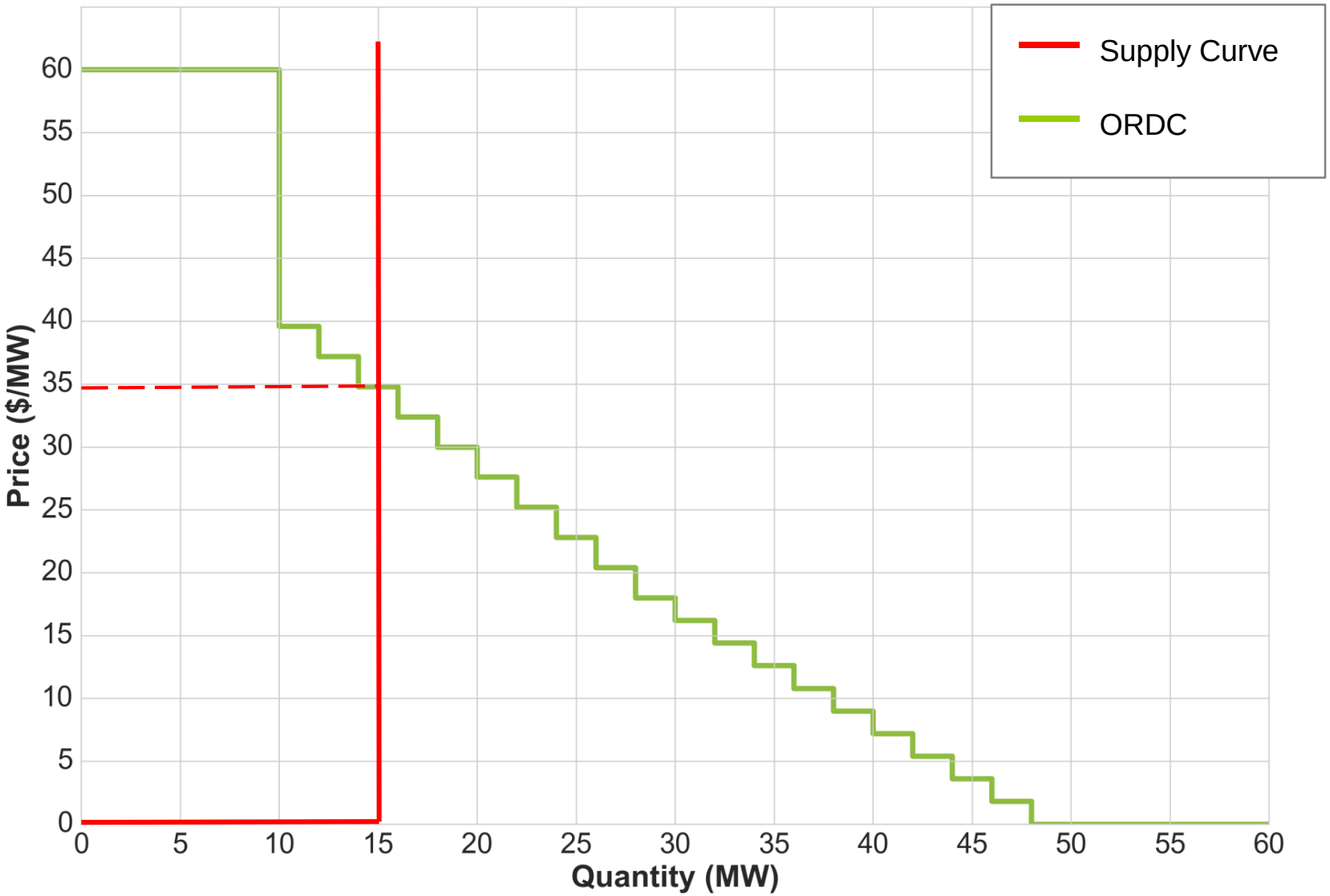
Example #3: Ramp Constrained



Example #3: Results



Example #3: Results - ORDC



Co-Optimizing Energy and Reserves – Example 3

Objective Function = cost to produce energy + cost to produce reserve – willing to pay for reserve

Objective Function = ($50/MW x 50 MW) + ($100/MW x 91 MW) + ($0 MW x 15 MW) - $790
= **$10,810**

If we need to serve 1 MW of additional energy:

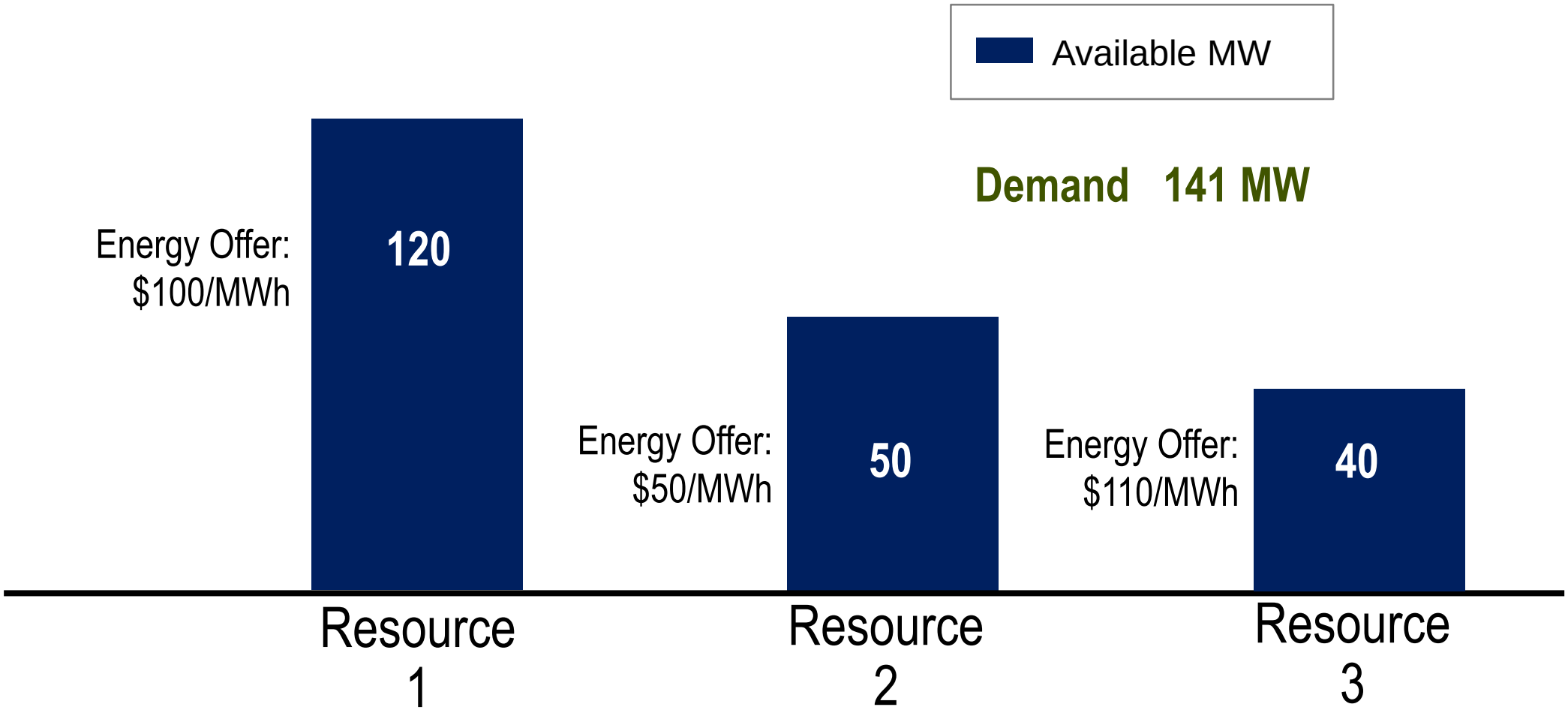
Objective Function (+1MW) = ($50/MW x 50 MW) + ($100/MW x **92 MW)** + ($0WW x 15 MW) - $790
= **$10,910**

The change in the Objective function to serve 1 MW of additional energy is:

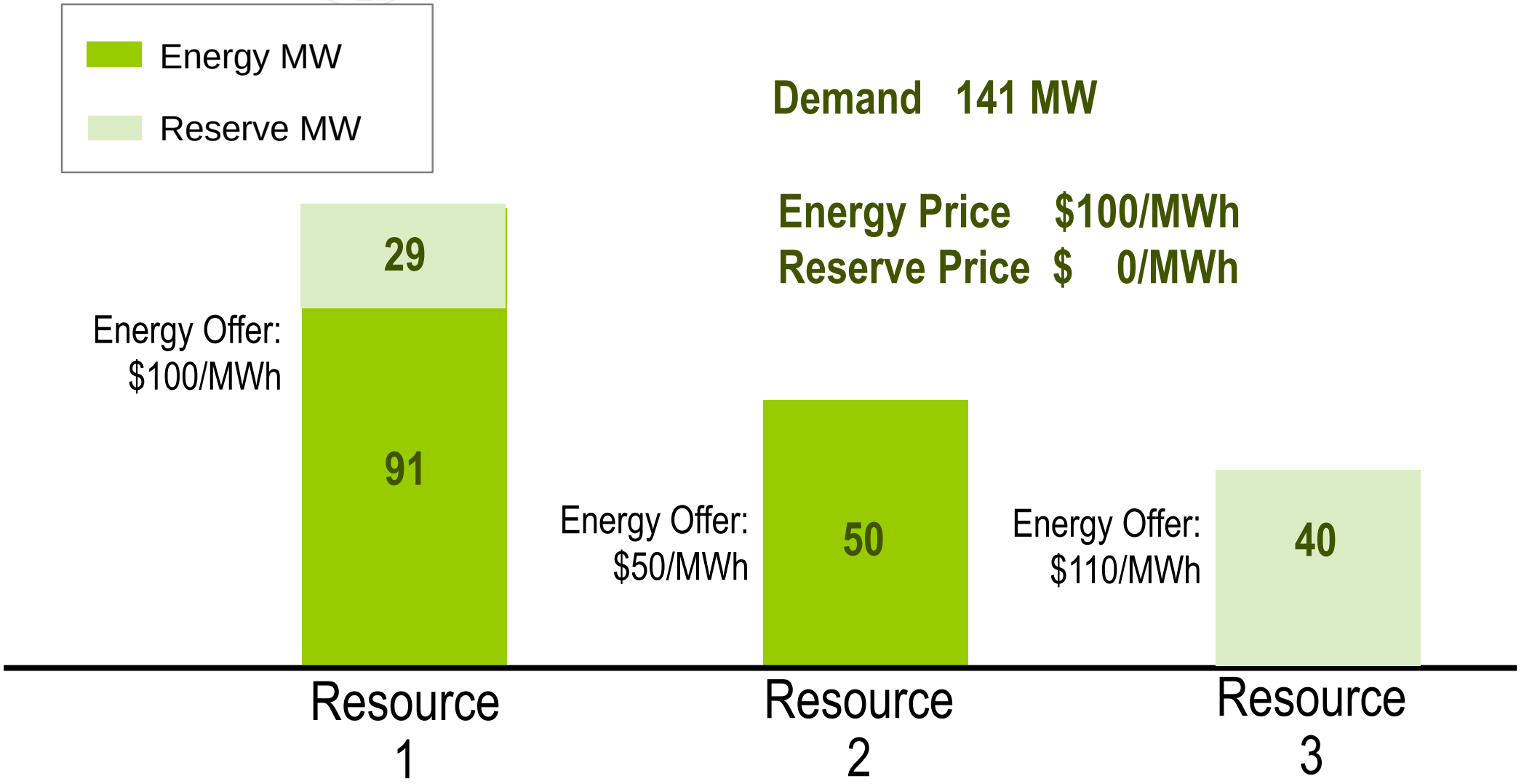
Change in Objective Function = $10,910 – $10,810
= $100

Therefore, the energy clearing price is $100/MWh. Note that, **for this particular example**, the reserve price ($35/MWh) **is not** added to the original energy-only price ($100/MWh)

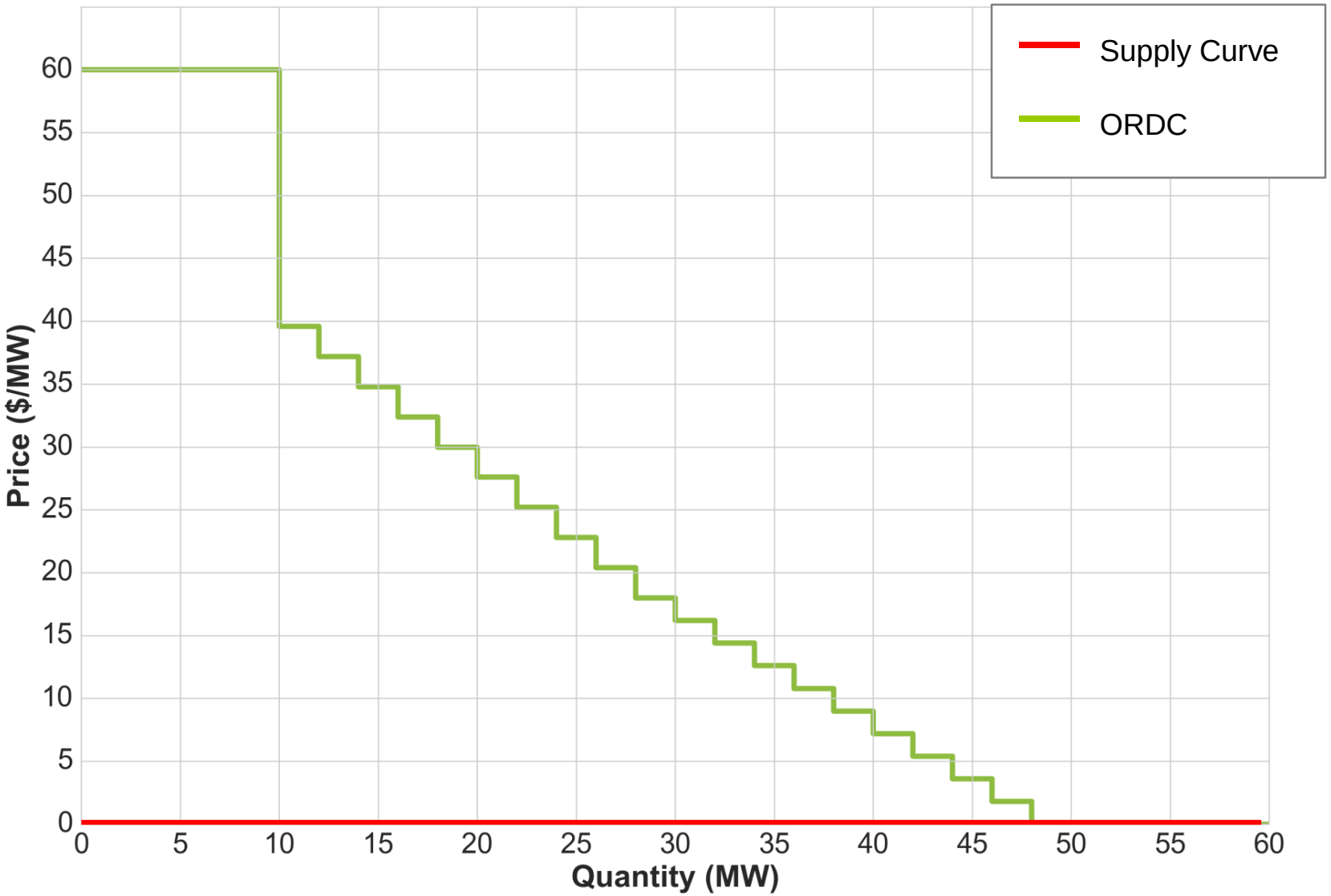
Example #4: Reserves Surplus



Example #4: Results



Example #4: Results - ORDC



Co-Optimizing Energy and Reserves – Example 4

Objective Function = cost to produce energy + cost to produce reserve – willing to pay for reserve

Objective Function = ($50/MW x 50 MW) + ($100/MW x 91 MW) + ($0 MW x 69 MW) - $1280
= **$10,320**

If we need to serve 1 MW of additional energy:

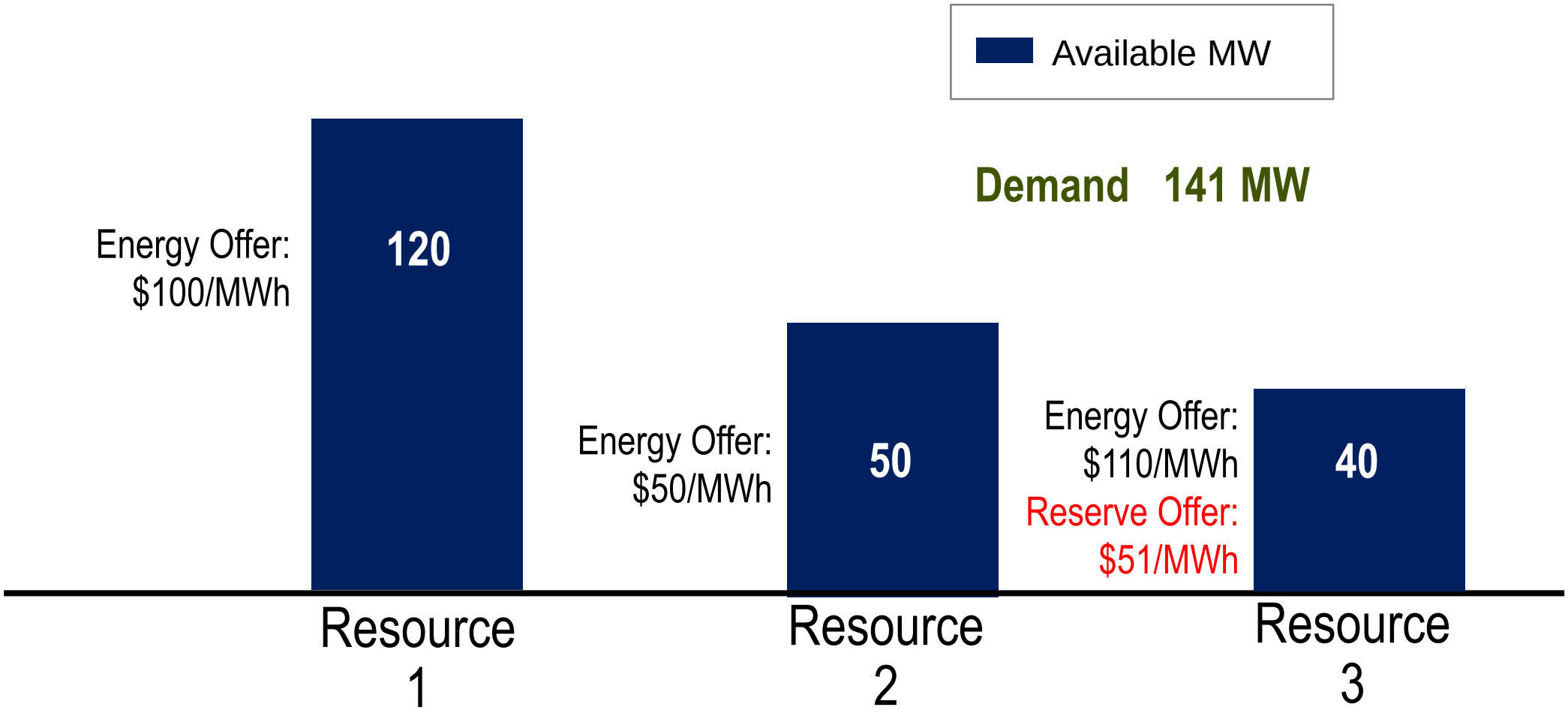
Objective Function (+1MW) = ($50/MW x 50 MW) + ($100/MW x **92 MW)** + ($0WW x **68 MW**) - $1280
= **$10,420**

The change in the Objective function to serve 1 MW of additional energy is:

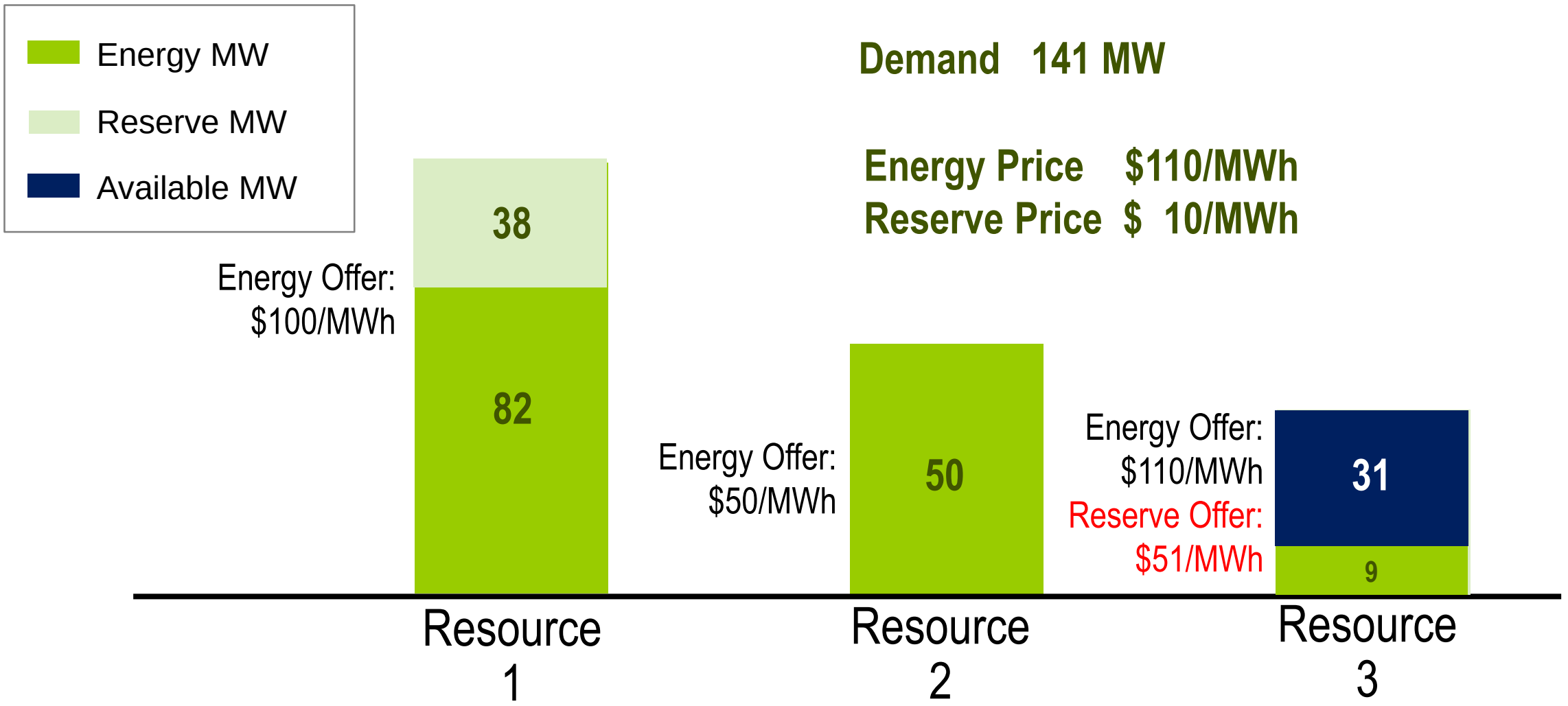
Change in Objective Function = $10,420 – $10,320
= $100

Therefore, the energy clearing price is $100/MWh. The reserve clearing price of ($0/MWh) does not impact the original energy-only price ($100/MWh)

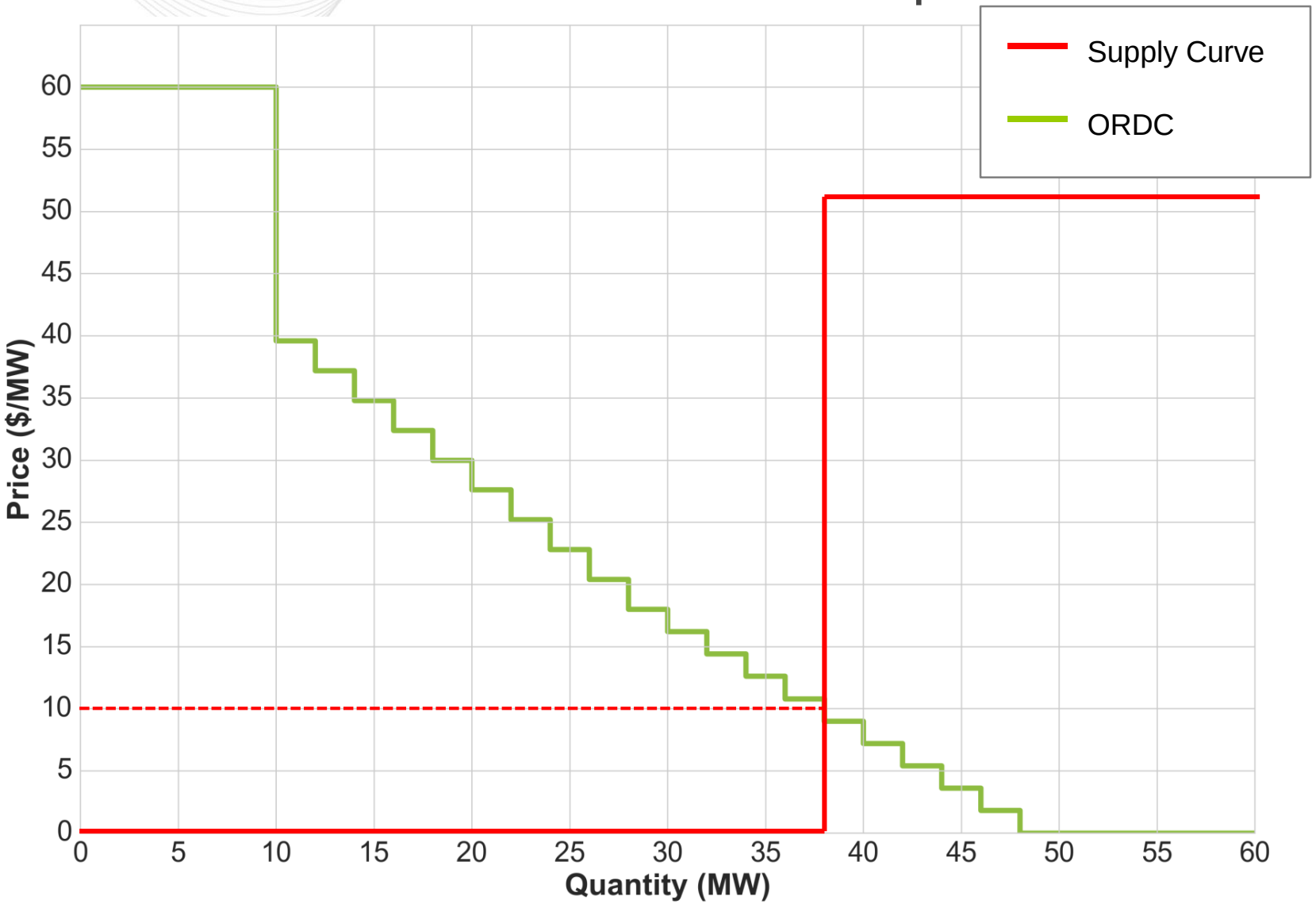
Example #5: Reserves Economic Shortage



Example #5: Results



Example #5: Results - ORDC



Co-Optimizing Energy and Reserves – Example 5

Objective Function = cost to produce energy + cost to produce reserve – willing to pay for reserve

Objective Function = ($50/MW x 50 MW) + ($100/MW x 82 MW) + ($110/MW x 9) + ($0 MW x 38 MW) - $1250
= **$10,440**

If we need to serve 1 MW of additional energy:

Objective Function (+1MW) = ($50/MW x 50 MW) + ($100/MW x 82 MW) + ($110/MW x **10 MW)** + ($0 MW x 38 MW) - $1250
= **$10,550**

The change in the Objective function to serve 1 MW of additional energy is:

Change in Objective Function = $10,550 – $10,440
= $110

Therefore, the energy clearing price is $110/MWh. The reserve clearing price of ($10/MWh) does not impact the original energy-only price ($110/MWh)

Resource 1 is indifferent to providing energy or reserves due to the co-optimization of energy and reserves

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