

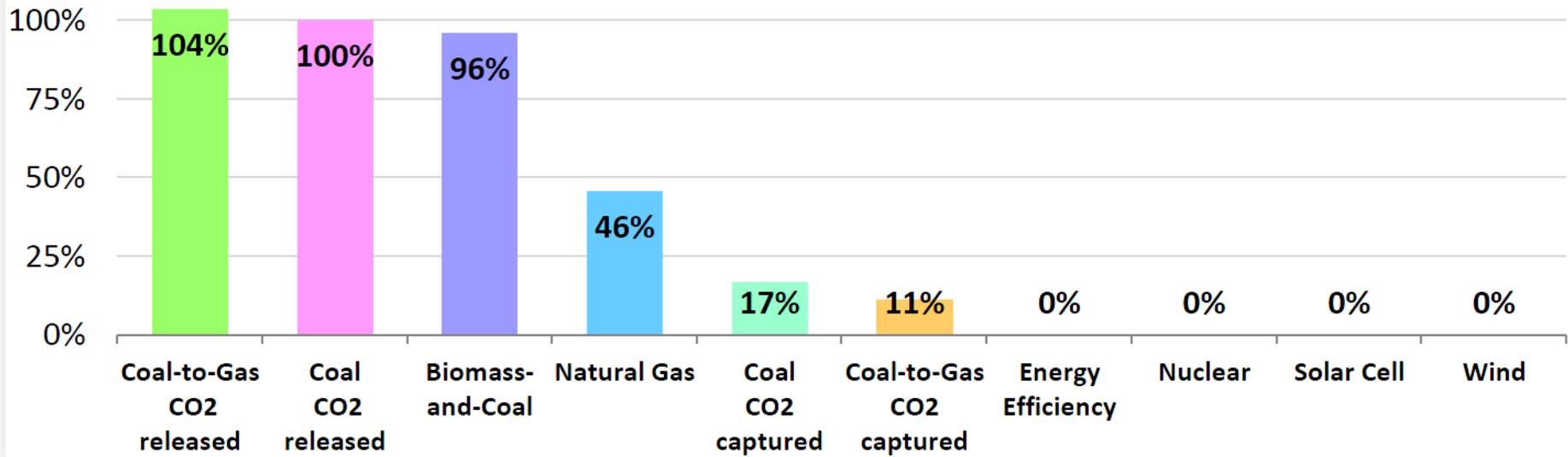
Electricity Tradeoffs

There are pros and cons to all power plant types

- Each power plant has different:
 - CO₂ emissions
 - Costs
 - Other types of air pollution that cause health problems
 - Water impacts (amount used and pollution)
 - Land impacts
 - Amounts of electricity that it can produce

CO₂ Released

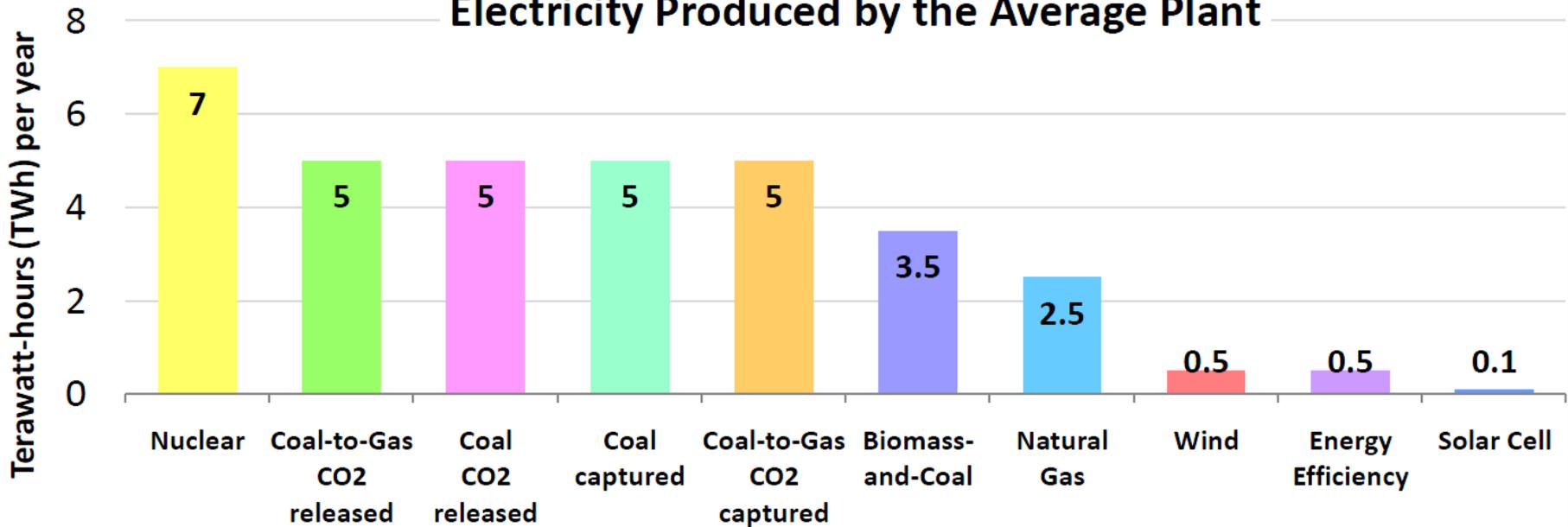
Carbon Dioxide Released (compared to Coal - CO₂ released)



Electricity Produced

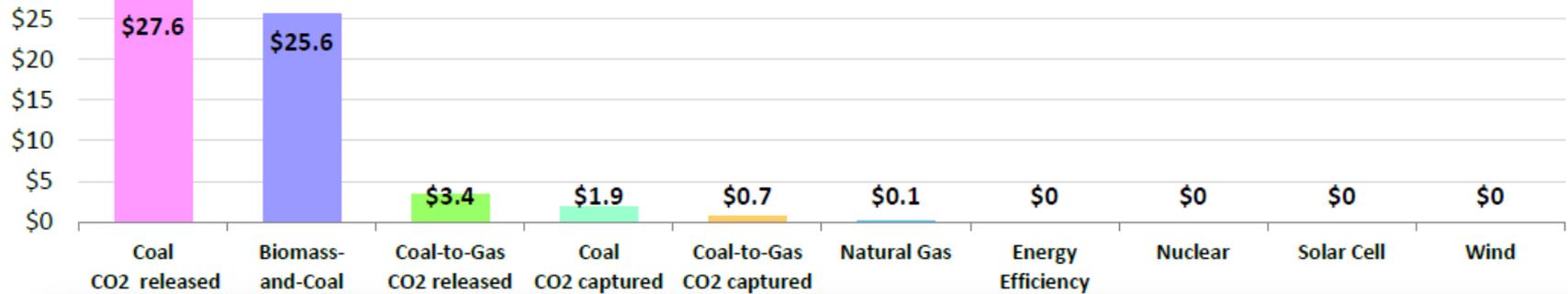
- Today, the power plants in PA make about 225 terawatt-hours (TWh) of electricity each year.
- A TWh is a measure of electricity use.
- One TWh is a lot of electricity. In comparison, an average household in PA uses less than 0.001% of one TWh of electricity per year.

Electricity Produced by the Average Plant

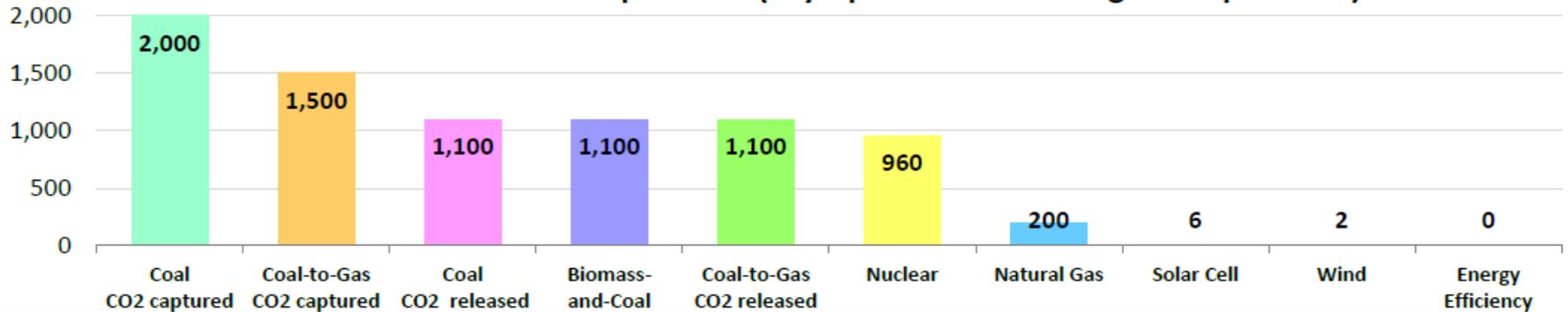


Environmental Impacts

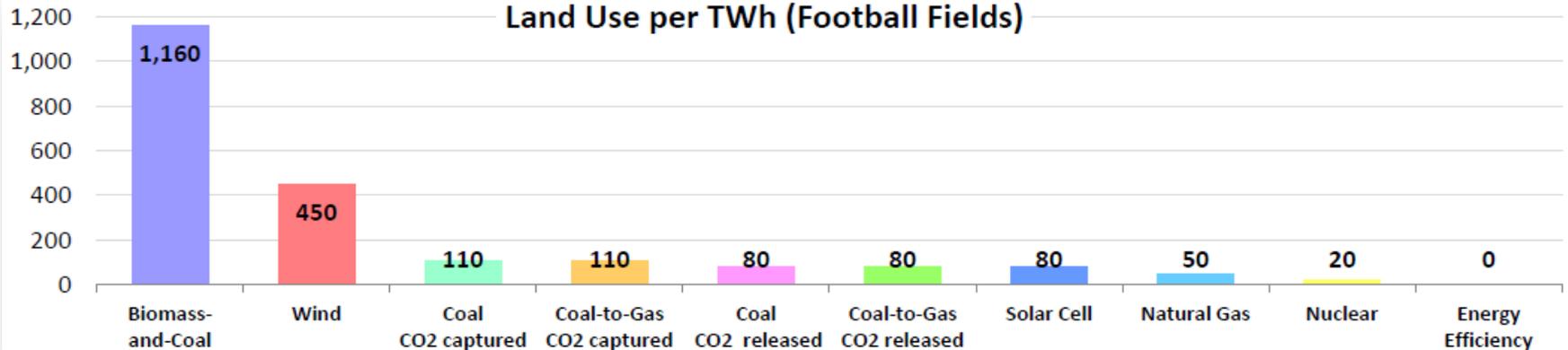
Annual Health Costs from Air Pollution (\$Million per TWh)



Annual Water Use per TWh (Olympic-Size Swimming Pools per TWh)



Land Use per TWh (Football Fields)



Cost Comparison

Average PA Household

- pays \$0.11 per kWh
- uses 700 kWh per month

Average Monthly Electric Bill

$$\$0.11 \times 700 = \$77$$

If your electric bill **goes up by**

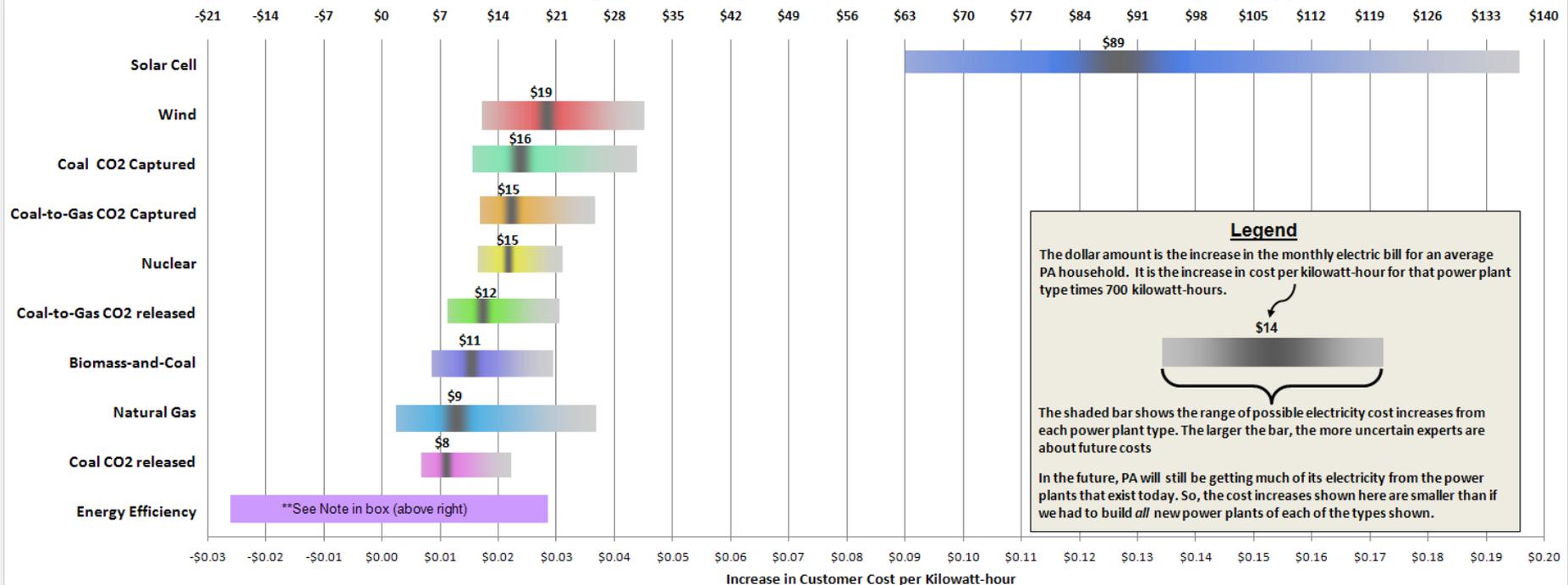
- \$0.01 per kWh
- uses 700 kWh per month

Increase in Monthly Electric Bill

$$\$0.01 \times 700 = \$7$$

So, your total bill would be
 $\$77 + \$7 = \$84$

Increase in Average Monthly Electric Bill from Each Power Plant Type



WHAT IF....

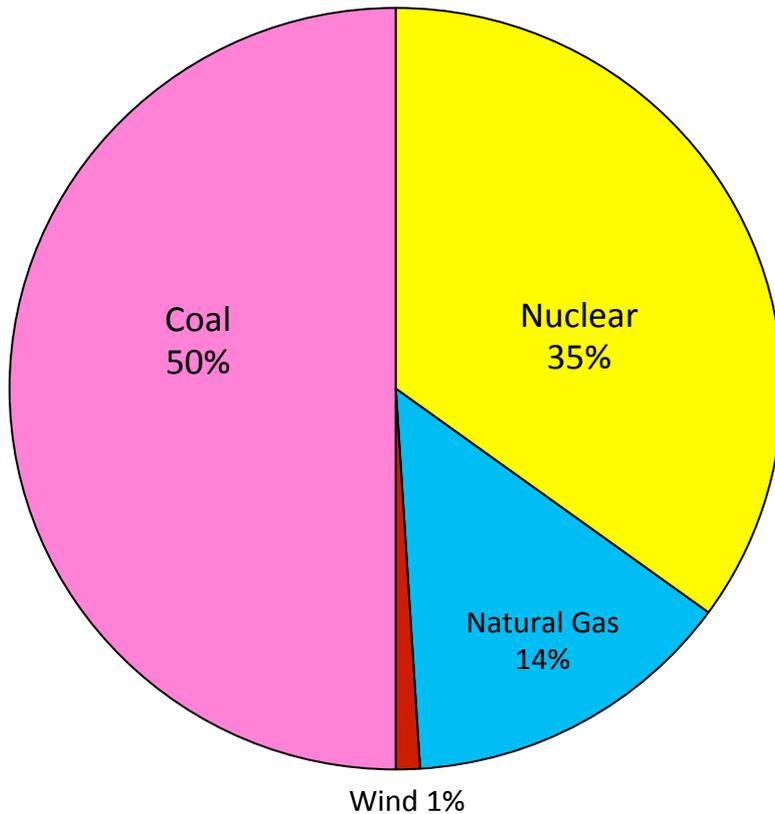
U.S. Congress passed a law that PA had to reduce the amount of CO₂ released from all power plants built in the future

In the next 25 years, the demand for electricity will increase.

- Existing power plants produce 225 TWh/year
- New power plants will need to make an additional 60 TWh/year

The Original Plan

Electricity Made by Plant Type



New Power Plant Construction

- **50% Coal**
 - 6 new coal plants = 30 TWh
- **35% Nuclear**
 - 3 new nuclear plants = 21 TWh
- **14% Natural Gas**
 - 4 new natural gas plants = 9 TWh
- **1% Wind**
 - 1 new wind farm = 0.5 TWh

The Original Plan

- Electricity Produced: 60.2 TWh
- CO₂ Released: 100%
- Annual Water Use: 56,000 Olympic Pools
- Land Use: 3,400 Football Fields
- Annual Health Cost: \$830 Million
- Increase in Monthly Electric Bill: \$8.35 or 11%
- Increased cost of everything else you buy: 1%

Your Problem Question

- Need power plants to make the additional 60 TWh of electricity for PA each year.
- BUT: U.S. Congress requires that the combination of power plants you build will collectively need to release 50% less CO₂ than the original plan.

Your Task

- Use computer tool to build a combination of new power plants that you think is the best.

Power Plant Combinations

Computer Tool

MAKE YOUR OWN POWER PLANT COMBINATION

BUILD CENTER

Biomass-and-Coal 0 TWh

Coal:
CO2 released 0 TWh

Coal:
CO2 captured 0 TWh

Coal-to-Gas:
CO2 released 0 TWh

Coal-to-Gas:
CO2 captured 30 TWh

Energy Efficiency 0 TWh

Natural Gas 20.6 TWh

Nuclear 7 TWh

Solar Cell 0 TWh

Wind 7 TWh

Percent Electricity Goal

Legend:
 Percent of electricity made by plant type
 Natural Gas needed to backup solar and wind

GOAL CENTER

Electricity Produced
64.6 TWh

Goal Reached!

CO₂ released
38%

Keep below 50%!

Limit: 50%

SAVE UP TO THREE COMBINATIONS

REVIEW & SAVE

IMPACTS

	Original Plan	Your Combination	% Change
Water Use (Olympic Pools/year)	56,000	55,400	-1%
Land Use (Football Fields)	3,400	7,700	126%
Health Costs (\$Millions/year)	\$830	\$20	-98%

COSTS

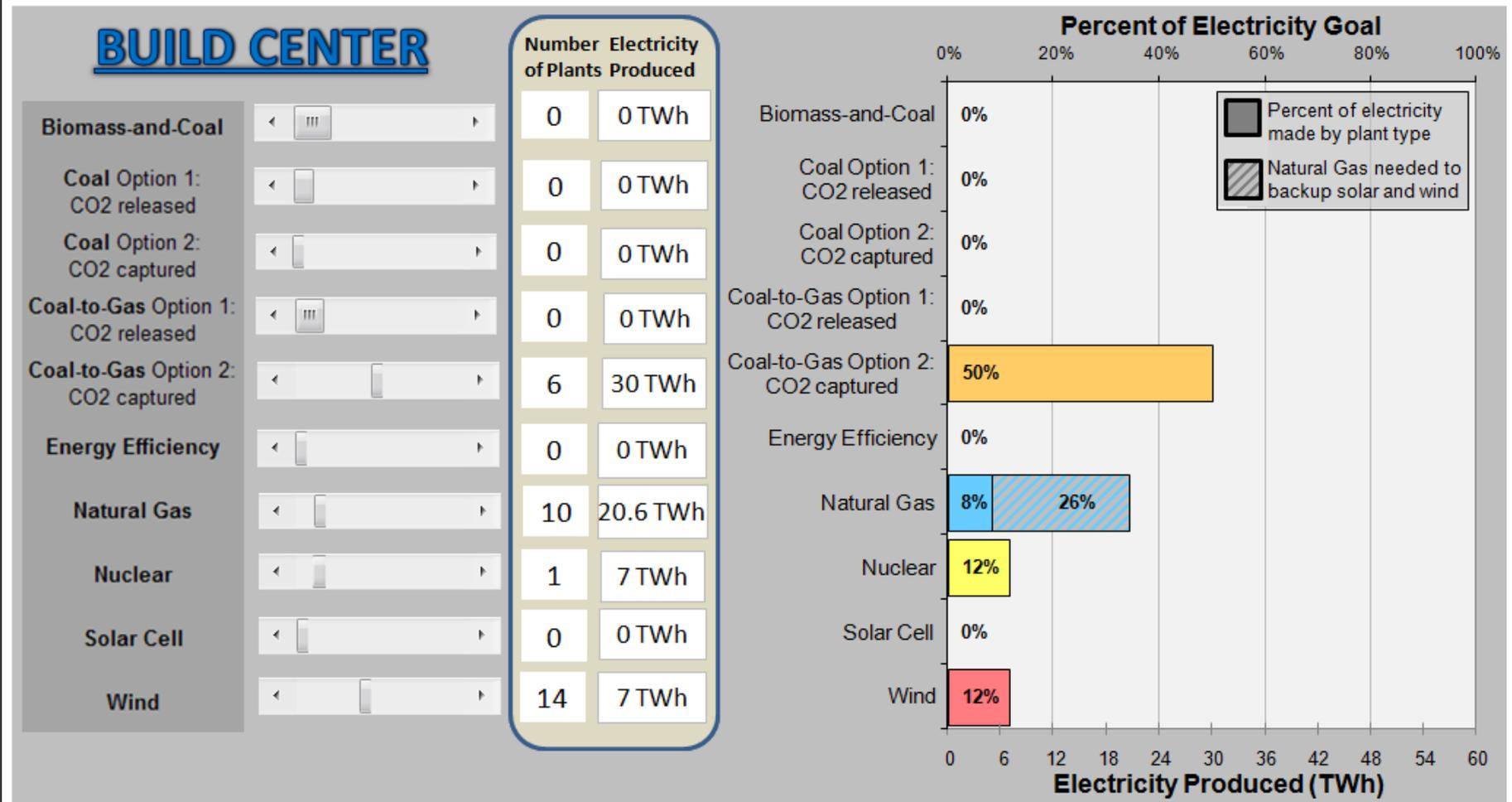
Average monthly electric bill of \$77 will increase by:

\$15.02 or 19%

Cost of everything else you buy will increase by:

2%

Build Center



Computer Tool

MAKE YOUR OWN POWER PLANT COMBINATION

BUILD CENTER

Biomass-and-Coal 0 TWh

Coal:
CO2 released 0 TWh

Coal :
CO2 captured 0 TWh

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Coal-to-Gas :
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Energy Efficiency 0 TWh

Natural Gas 20.6 TWh

Nuclear 7 TWh

Solar Cell 0 TWh

Wind 7 TWh

Percent of Electricity Goal

Legend:
 Percent of electricity made by plant type
 Natural Gas needed to backup solar and wind

Electricity Produced

64.6 TWh

Goal Reached!

108% GOAL

CO₂ released

38%

Keep below 50%!

--LIMIT

SAVE UP TO THREE COMBINATIONS

REVIEW & SAVE

Average monthly electric bill of \$77 will increase by:

\$15.02 or 19%

Cost of everything else you buy will increase by:

2%

IMPACTS

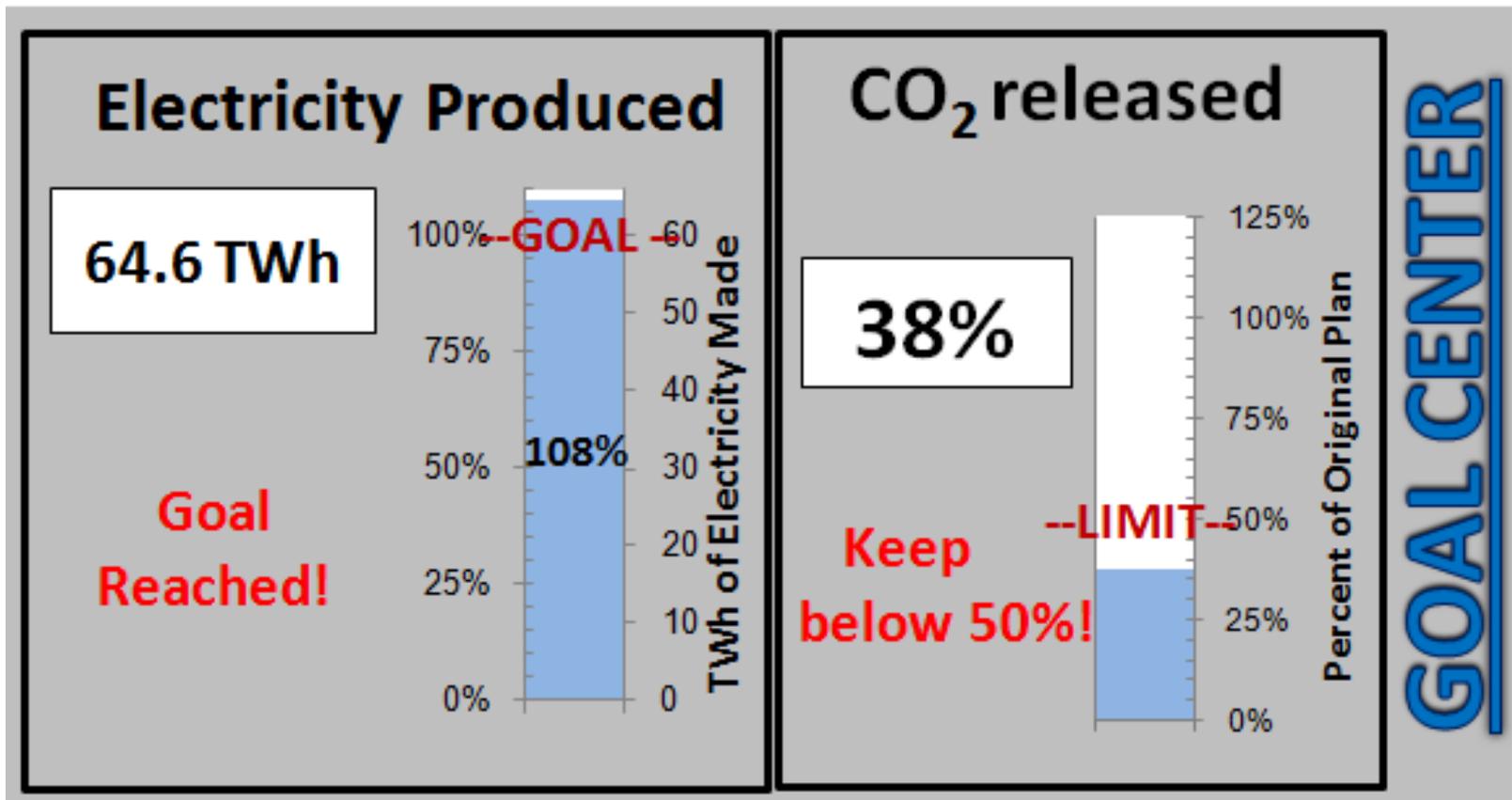
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COSTS

Monthly Electric Bill Increase: Original Plan \$11, Your combination \$15

Increased Cost per kilowatt-hour: Original Plan \$0.01, Your combination \$0.02

Goal Center



Computer Tool

MAKE YOUR OWN POWER PLANT COMBINATION

BUILD CENTER

Biomass-and-Coal 0 TWh

Coal:
CO2 released 0 TWh

Coal :
CO2 captured 0 TWh

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Energy Efficiency 0 TWh

Natural Gas 20.6 TWh

Nuclear 7 TWh

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Wind 7 TWh

Percent of Electricity Goal

Legend:
 Percent of electricity made by plant type
 Natural Gas needed to backup solar and wind

Electricity Produced

64.6 TWh

100% **GOAL** -60
 75%
 50% **108%**
 25%
 0%

Goal Reached!

TWh of Electricity Made

CO₂ released

38%

125%
 100%
 75%
 50% **LIMIT**
 25%
 0%

Keep below 50%!

Percent of Original Plan

SAVE UP TO THREE COMBINATIONS

REVIEW & SAVE

Average monthly electric bill of \$77 will increase by:

\$15.02 or 19%

Cost of everything else you buy will increase by:

2%

IMPACTS

	Original Plan	Your Combination	% Change
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COSTS

Impacts

IMPACTS

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Computer Tool

MAKE YOUR OWN POWER PLANT COMBINATION

BUILD CENTER

Biomass-and-Coal 0 TWh

Coal: 0 TWh

Coal : 0 TWh

Coal-to-Gas : 0 TWh

Coal-to-Gas : 30 TWh

Energy Efficiency 0 TWh

Natural Gas 20.6 TWh

Nuclear 7 TWh

Solar Cell 0 TWh

Wind 7 TWh

Percent of Electricity Goal

Legend:
 Percent of electricity made by plant type
 Natural Gas needed to backup solar and wind

Electricity Produced

64.6 TWh

Goal Reached!

CO₂ released

38%

Keep below 50%!

SAVE UP TO THREE COMBINATIONS

REVIEW & SAVE

IMPACTS

	Original Plan	Your Combination	% Change
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COSTS

Average monthly electric bill of \$77 will increase by:

\$15.02 or 19%

Cost of everything else you buy will increase by:

2%

GOAL CENTER

COSTS

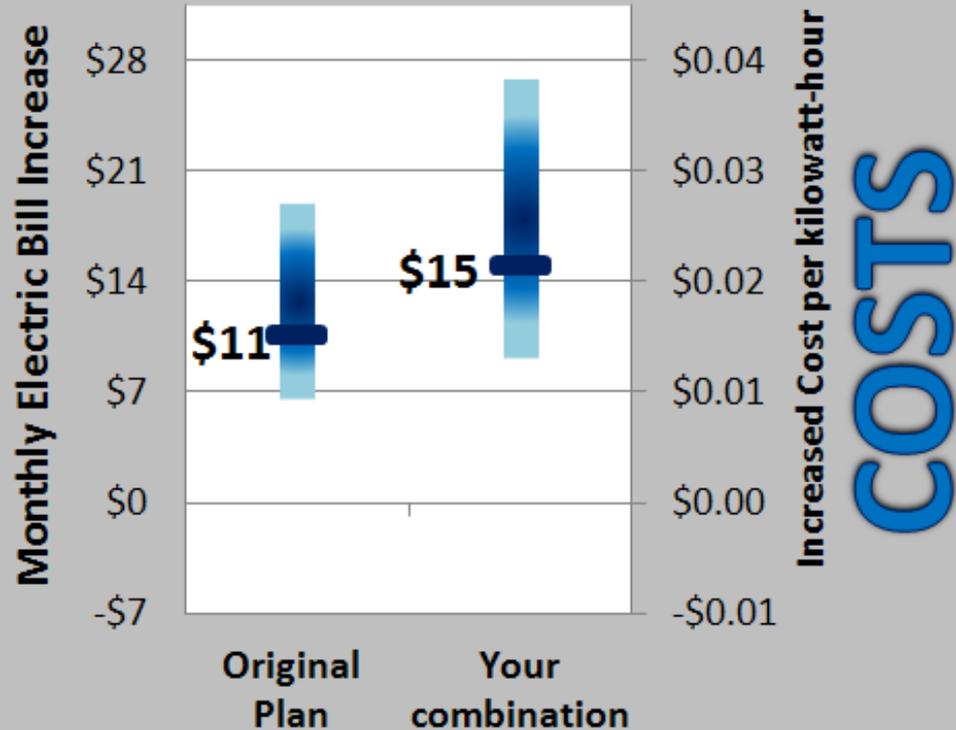
Costs

Average monthly electric bill of \$77 will increase by:

\$15.02 or **19%**

Cost of everything else you buy will increase by:

2%



Computer Tool

MAKE YOUR OWN POWER PLANT COMBINATION

BUILD CENTER

Biomass-and-Coal 0 TWh

Coal:
CO2 released 0 TWh

Coal :
CO2 captured 0 TWh

Coal-to-Gas :
CO2 released 0 TWh

Coal-to-Gas :
CO2 captured 30 TWh

Energy Efficiency 0 TWh

Natural Gas 20.6 TWh

Nuclear 7 TWh

Solar Cell 0 TWh

Wind 7 TWh

Percent of Electricity Goal

Legend:
 Percent of electricity made by plant type
 Natural Gas needed to backup solar and wind

Plant Type	Percent of Goal	Electricity Produced (TWh)
Biomass-and-Coal	0%	0
Coal Option 1: CO2 released	0%	0
Coal Option 2: CO2 captured	0%	0
Coal-to-Gas Option 1: CO2 released	0%	0
Coal-to-Gas Option 2: CO2 captured	50%	30
Energy Efficiency	0%	0
Natural Gas	8% (26% with backup)	20.6
Nuclear	12%	7
Solar Cell	0%	0
Wind	12%	7

GOAL CENTER

Electricity Produced

64.6 TWh

Goal Reached!

CO₂ released

38%

Keep below 50%!

SAVE UP TO THREE COMBINATIONS

REVIEW & SAVE

IMPACTS

	Original Plan	Your Combination	% Change
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COSTS

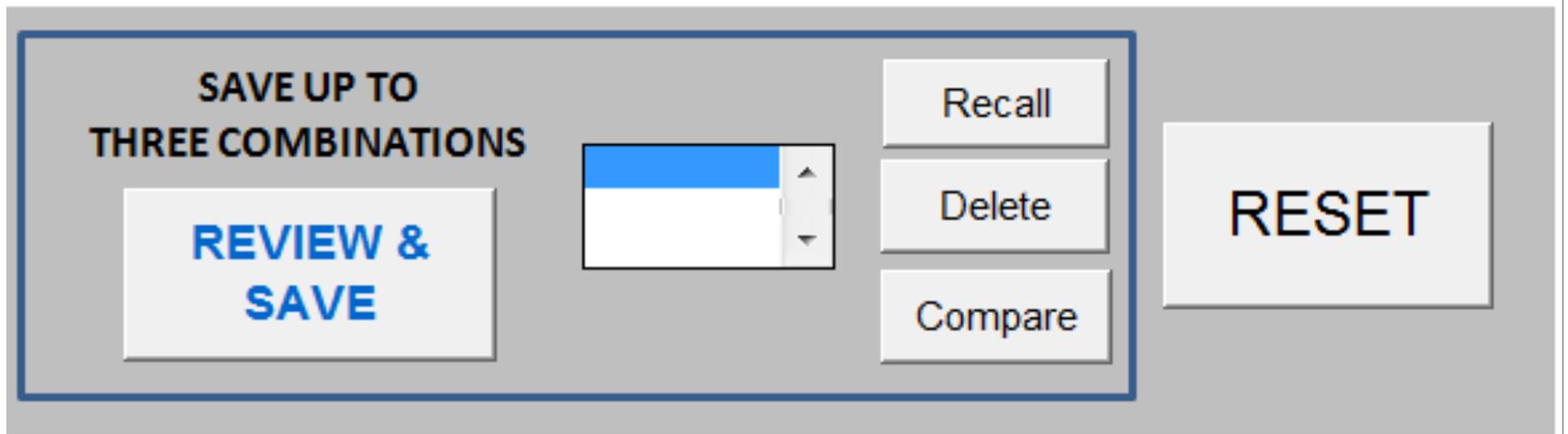
Average monthly electric bill of \$77 will increase by:

\$15.02 or 19%

Cost of everything else you buy will increase by:

2%

Controls



Controls

SAVE UP TO
THREE COMBINATIONS

**REVIEW &
SAVE**

combo 1
combo 2
combo 3

Recall

Delete

Compare

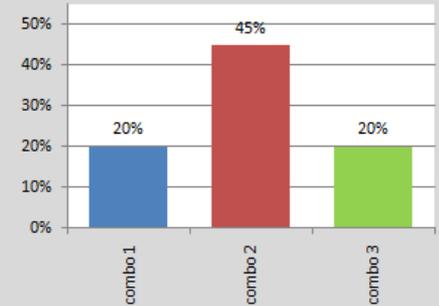
RESET

Compare

Your Combinations (Percent of Each Power Plant Type)

	combo 1	combo 2	combo 3
Biomass-and-Coal	0%	0%	0%
Coal Option 1: No CO ₂ capture	0%	17%	0%
Coal Option 2: CO ₂ Capture	0%	0%	0%
Coal-to-Gas Option 1: No CO ₂ capture	0%	0%	0%
Coal-to-Gas Option 2: CO ₂ Capture	50%	17%	0%
Energy Efficiency	0%	15%	20%
Natural Gas	36%	21%	59%
Nuclear	12%	23%	0%
Solar Cell	0%	0%	4%
Wind	12%	9%	14%

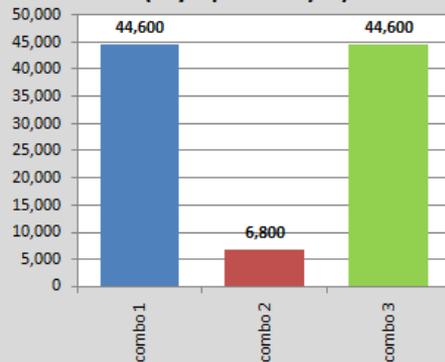
CO2 Released



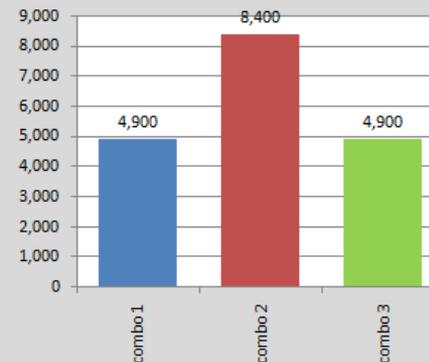
Monthly Electric Bill



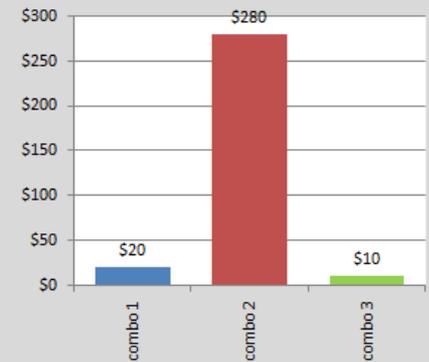
Water Use (Olympic Pools/Yr)



Land Use (Football Fields)



Health Costs (\$Millions/Yr)



Teacher Guided Group Exercise

- Explore the computer tool as a group to build a combination of power plants that you think is the best.
- Goals:
 - Need power plants to make the additional 60 TWh of electricity for PA each year.
 - BUT: U.S. Congress requires that the combination of power plants you build will collectively need to release 50% less CO₂ than the original plan.

New Problem Question

- Need power plants to make the additional 60 TWh of electricity for PA each year.
- The original plan was to build these power plants:
 - 6 Coal (Option 1) plants (50%)
 - 4 natural gas (15%)
 - 3 nuclear (35%)
 - 1 wind farm (1%)
- A new power plant combination will collectively need to release 50% less CO₂ than the original plan.

Your Task

- **Use computer tool to build a combination of new power plants that you think is the best.**
- **The combination must make 60 TWh of electricity per year, but release 50% of the CO₂ that would have been released using the original plan.**

Step-by-step exercise