Simple Boiler

Creating a Dynamic Operating Strategy that Maximizes Shareholder Value using the Provisdom Decision Platform

Dynamic Operating Strategy

- Strategy can be changed regularly or at any time.
- Use information regarding changing and unknown operating costs.
- Make purchasing decisions based on operating strategy.

Provisdom Approach

- Fast feedback
  - First cut usually takes less than an hour of the decision maker or analyst's time and is completed by Provisdom in less than a day
  - Efforts focus on aligning model with corporation's information
- Use all relevant information
  - Whether data or human knowledge, qualitative or quantitative, even imperfect or incomplete
- Transparent models and results
  - Problem is discretized into as many as billions of possibilities
  - Model can be queried like a database, simulated, or viewed in a decision tree
- Maximize shareholder value
  - Create the strategy that maximizes shareholder value
  - Compare shareholder value of optimal strategy against previous strategy to find value added

Example: Operating a Boiler

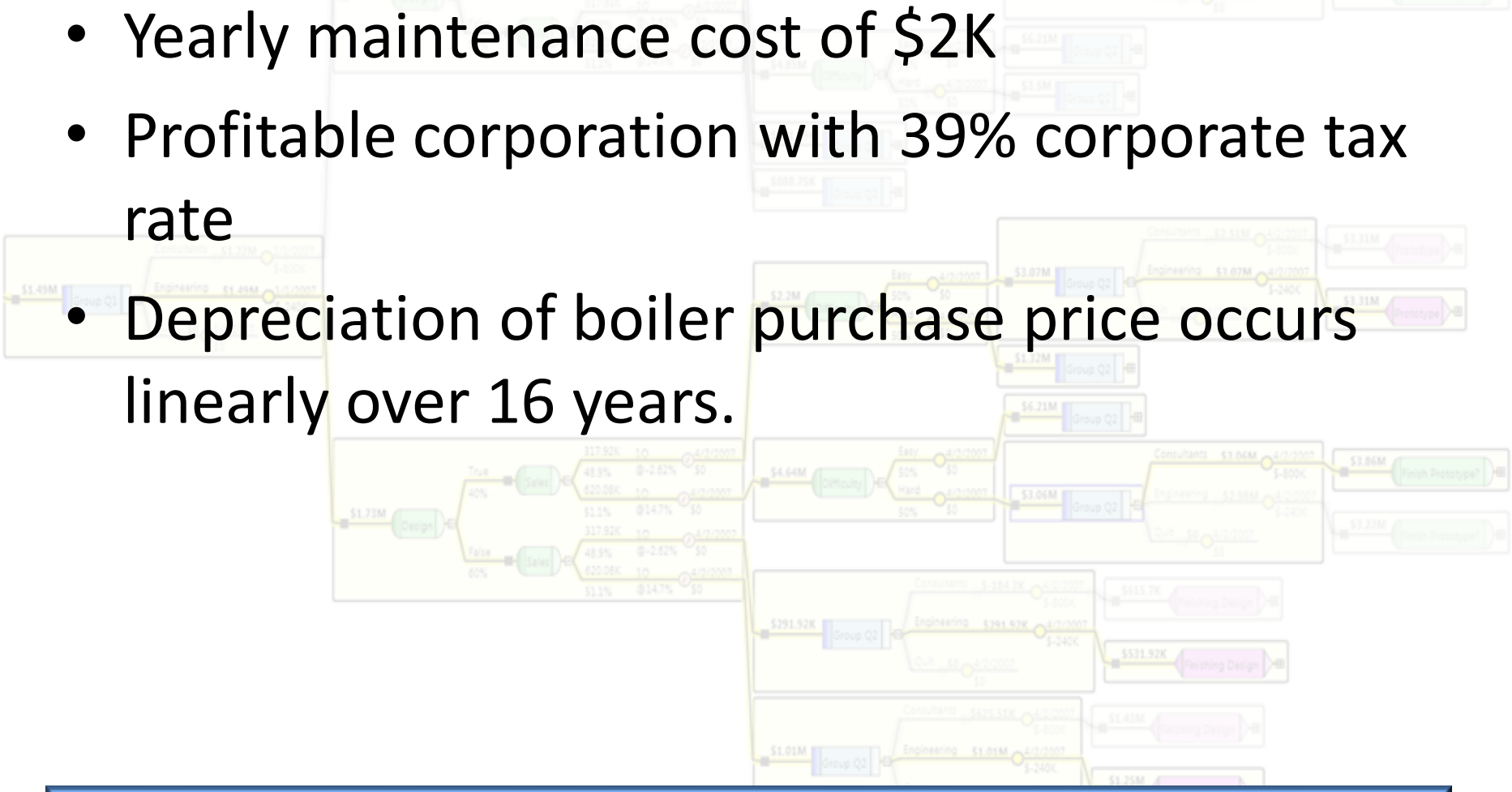
- New industrial boiler needed to run manufacturing plant for next 20 years.
- Three boilers from which to choose
  - Fuel Oil Boiler -- $200K
  - Natural Gas Boiler -- $190K
  - Dual Boiler (burns oil or gas) -- $225K
- Dual burner can switch between fuel types for a cost of $9K.
- Desire operating and purchasing strategy that maximizes shareholder value.

Fuel Oil and Natural Gas

- Trades on a public market
- At current market prices, yearly boiler fuel costs total
  - $28K with fuel oil
  - $29K with natural gas
- Uncertainty resembles geometric Brownian motion with constant growth and volatility
- Small, upward trend in prices (5% expected growth rate)
- Medium uncertainty
  - 13% volatility for fuel oil
  - 10% volatility for natural gas
- Market assigns no value or cost to fuel storage (0% yield)
- Strong, positive relationship between fuel oil and natural gas (30% correlation)

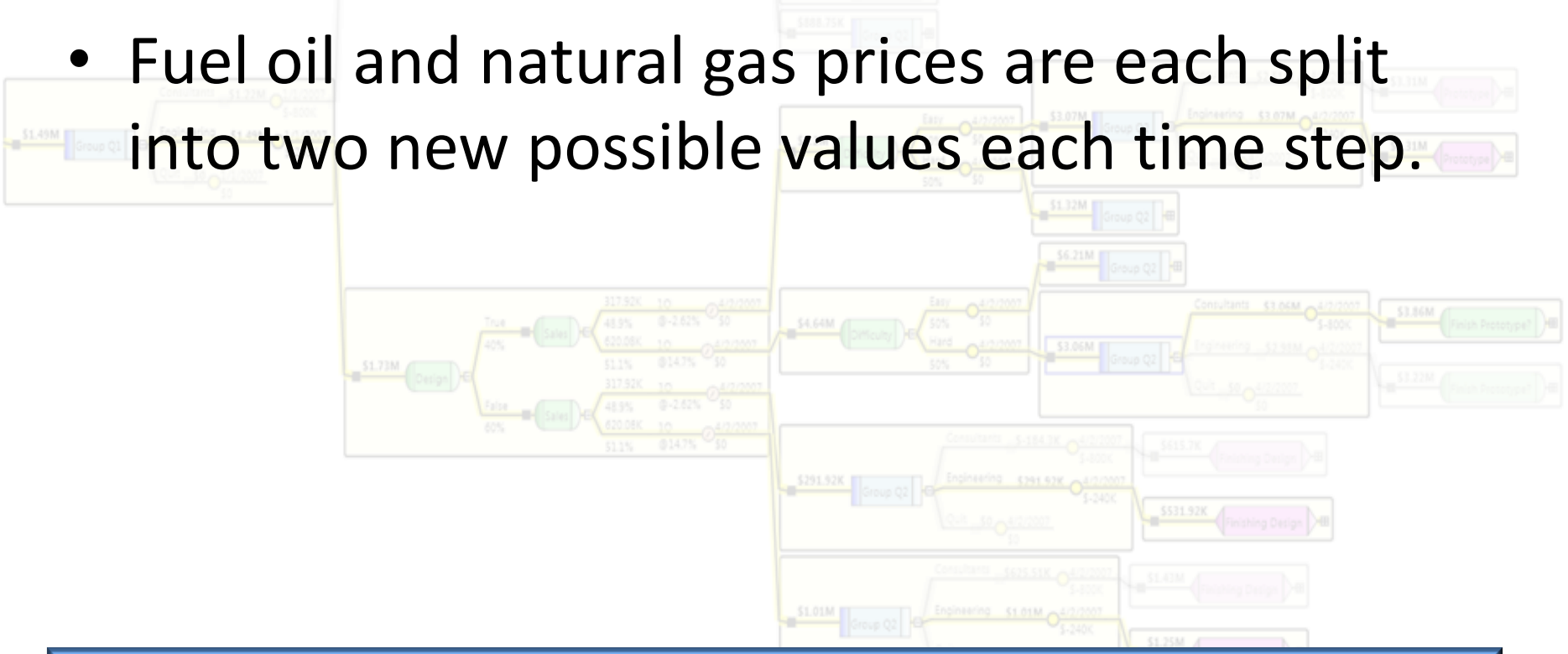
Free Cash Flow

- Yearly maintenance cost of $2K
- Profitable corporation with 39% corporate tax rate
- Depreciation of boiler purchase price occurs linearly over 16 years.



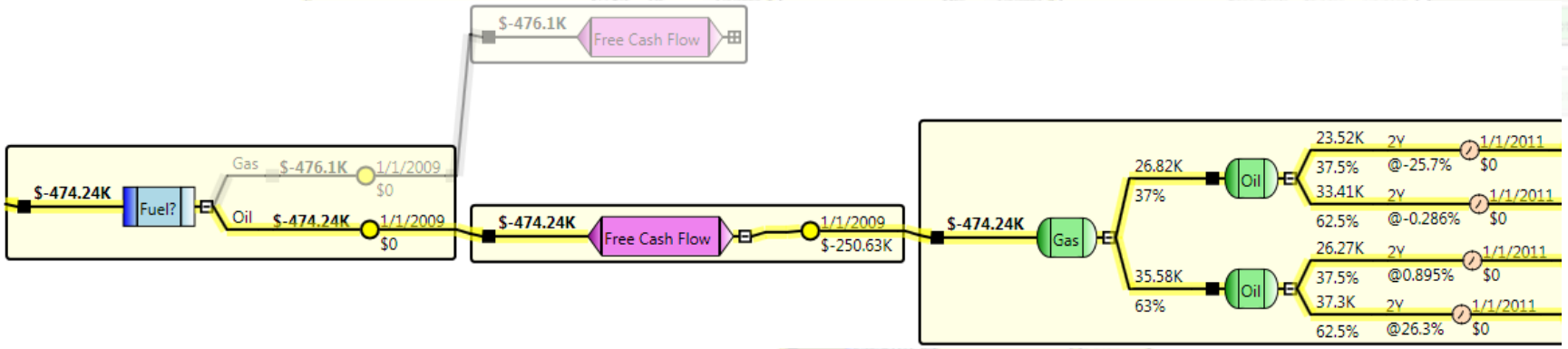
Building the Strategic Model

- 20-year boiler strategy is modeled in 2-year time steps.
- Fuel oil and natural gas prices are each split into two new possible values each time step.



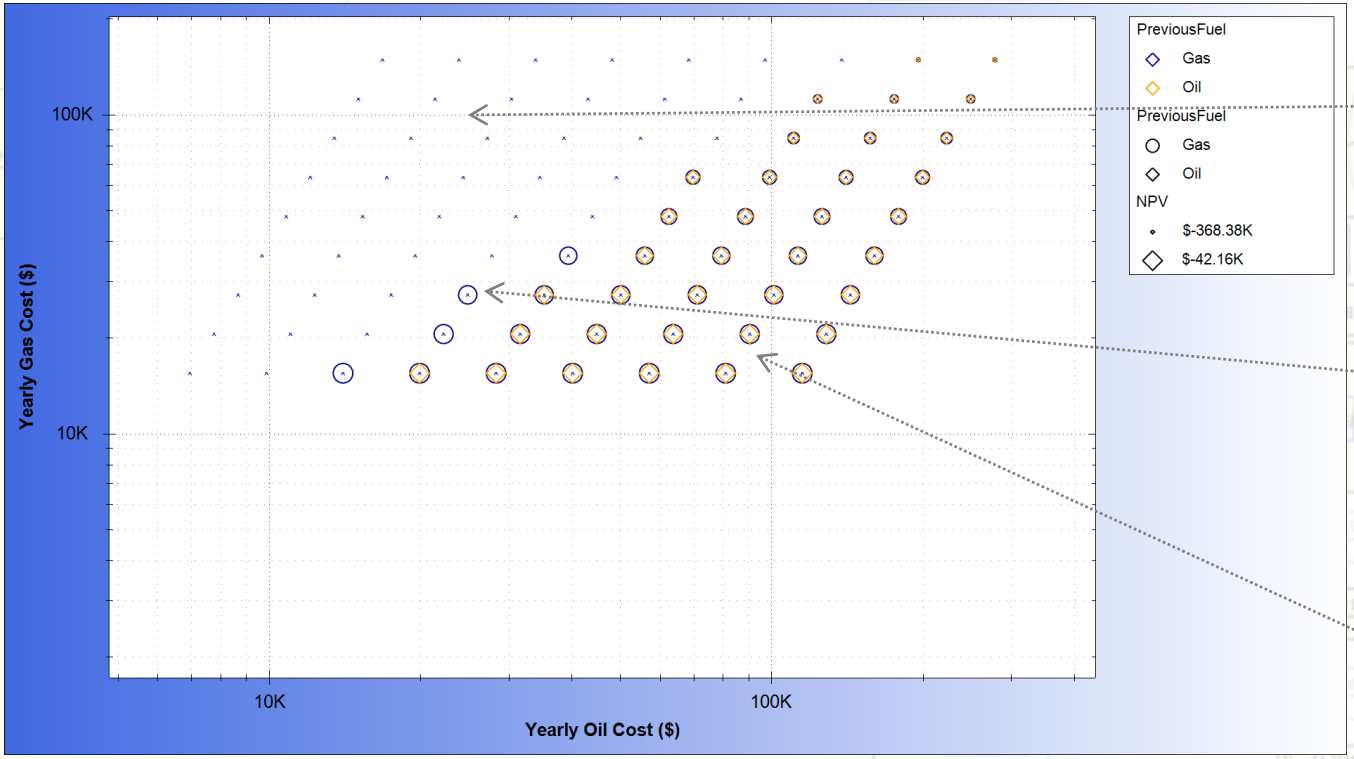
Model Feedback Sample: Screen Shot – Start of Decision Tree

- Useful for investigating model in detail.
- Highlights optimal-choice paths.
- In the tree below, the left-most blue rectangle represents the first fuel choice.
- Today's optimal choice is to purchase the Dual Boiler and burn oil, resulting in an NPV of -$474.24M.



Model Feedback Sample: Optimal Strategy for Burning Natural Gas

- Useful for investigating full strategy.
- Graph below shows only year 16.



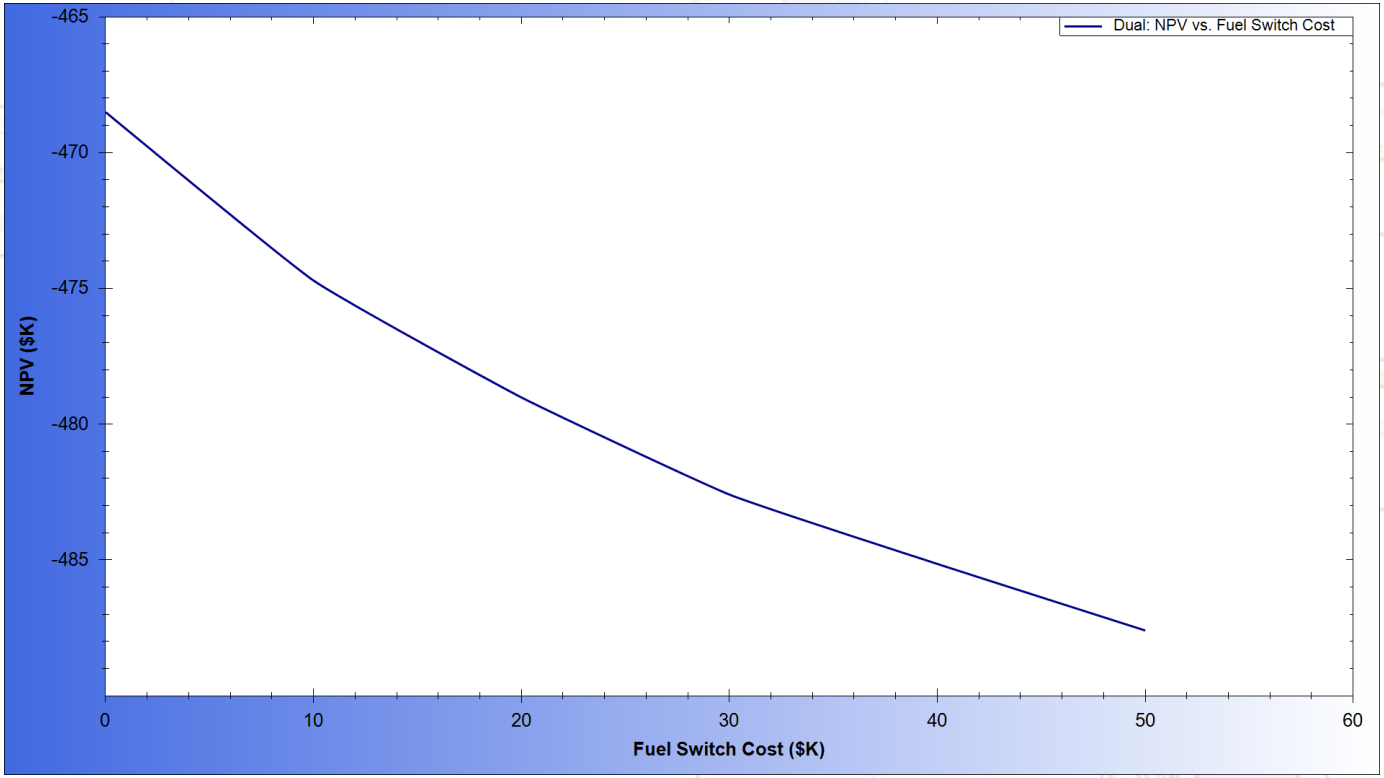
Don't burn gas when it's relatively expensive

Continue burning current fuel when prices are close to equal

Burn gas when it's relatively inexpensive

Model Feedback Sample: Queries
NPV of Optimal Strategy vs. Fuel Switching Cost

- Useful for providing insight into how model property changes affect value
- For example, lowering fuel switch cost from $9K to $3K would add approximately $4K in shareholder value.



Model Feedback Sample: Gradient Analysis

- A sensitivity analysis that calculates a change in shareholder value with a change in a model property value.
- Generally calculated with the optimal strategy and all the model properties at their original values.
- Similar to a Tornado diagram but arguably more relevant.
- The table below contains the nine model properties that were given in terms of percentages.

Model Property	d(NPV) / d(%)
Oil Yield	$13.6K
Gas Yield	$11.7K
Corporate Tax Rate	$7.0K
Oil Volatility	$2.6K
Risk-Free Rate	(-$2.6K)
Gas Volatility	$1.6K
Oil-Gas Correlation	(-$0.3K)
Oil Growth	$0.0
Gas Growth	$0.0

- Note that Corporate Tax Rate has a positive impact on the NPV because the model only considers costs.
- Also note that Oil and Gas Volatility have a positive impact on the NPV and the Correlation has a negative impact due to the option to switch fuels.
- Oil and Gas are Market assets
  - Thus, growth rate has no effect on NPV.
  - Yield has a large, positive impact on the NPV because higher yield implies lower risk-adjusted prices in the future.

Strategy that Maximizes Shareholder Value

- Today's optimal choice is to purchase the Dual Boiler and burn fuel oil.
- To continue to get the most accurate optimal strategy over time, automatically or manually feed new state variable values into software.
- Full twenty-year strategy is dynamic and complex, roughly:
  - Continue with current fuel to avoid switching costs when fuel costs are relatively close.
  - Burn oil when oil is relatively cheaper than gas.
  - Burn gas when gas is relatively cheaper than oil.

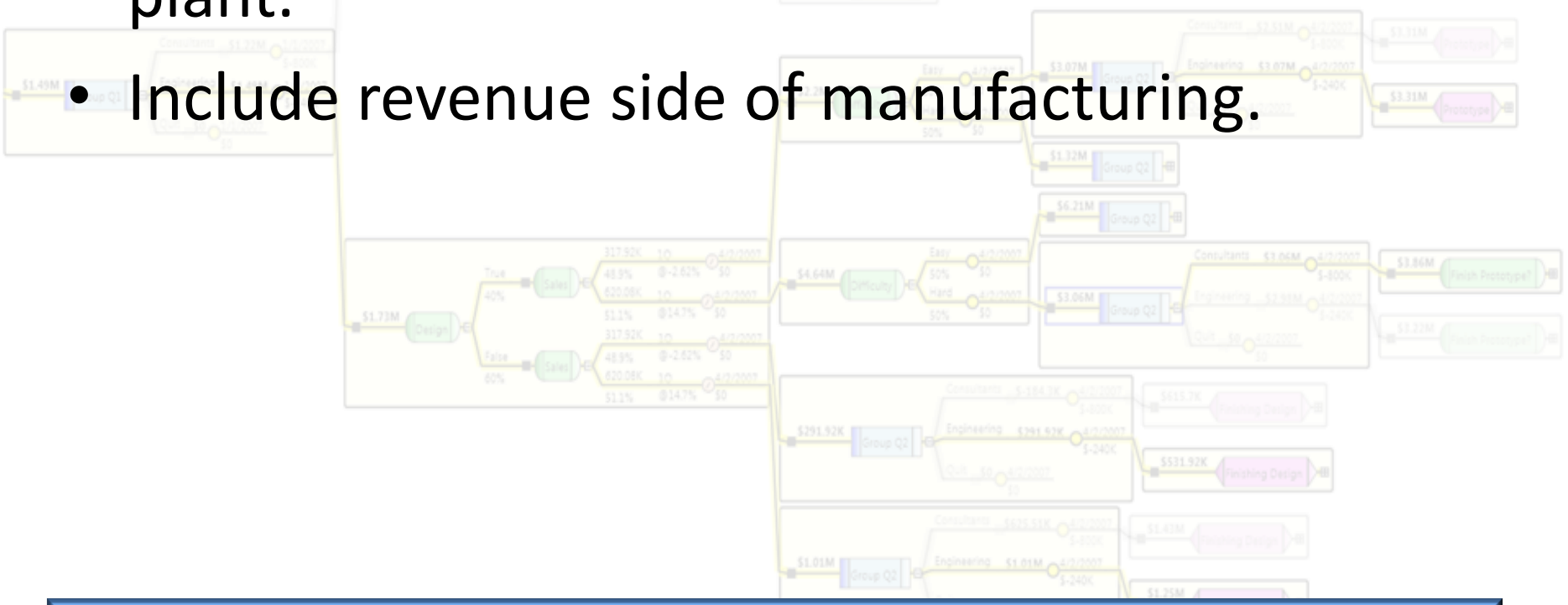
Strategy Comparisons

- Useful for calculating shareholder value added by analysis.
- Table below compares optimal strategy to a strategy of purchasing the Oil Boiler and to a strategy of purchasing the Gas Boiler.
- The comparisons are in terms of shareholder value, in both absolute and percentage terms.

Strategy	NPV	$ increase to optimal	% decrease from optimal
Optimal Strategy	-$474.24K	$0	0%
Oil Boiler	-$498.17K	$23.93K	-5.0%
Gas Boiler	-$503.53K	$29.29K	-6.2%

Example Modifications and Extensions

- Extend model by adding decisions to replace the boiler, lease a boiler, or shut down the plant.
- Include revenue side of manufacturing.



Summary of Provisdom Process

1. Gather Initial Information
2. Map Business Problem to Software (using Information Rules)
3. Run Initial Model
   - Find and execute next rule.
   - Find probabilities with a nonlinear optimization solver.
   - Discretize continuously-valued uncertainties and time.
   - Calculate proper discount rates.
4. Analyze Results
5. Refine Model
6. Automate or Update Model Periodically

```
constrain OilPrice in Money &&
    Growth = prop(Oil.Growth) &&
    Volatility = prop(Oil.Volatility) &&
    Yield = prop(Oil.Yield);
```