IRP Risk Analysis

IRP and Modeling

August 3, 2017

DTE Electric Risk Analysis for IRP

DTE Energy

The intent for this presentation is to educate the stakeholders on the risk analysis process used in Integrated Resource Planning

DTE Electric will not answer questions today about why or how we settled on our assumptions or obtained our data. We will answer process questions only

The 2017 DTE Electric Integrated Resource Plan was filed July 31, 2017

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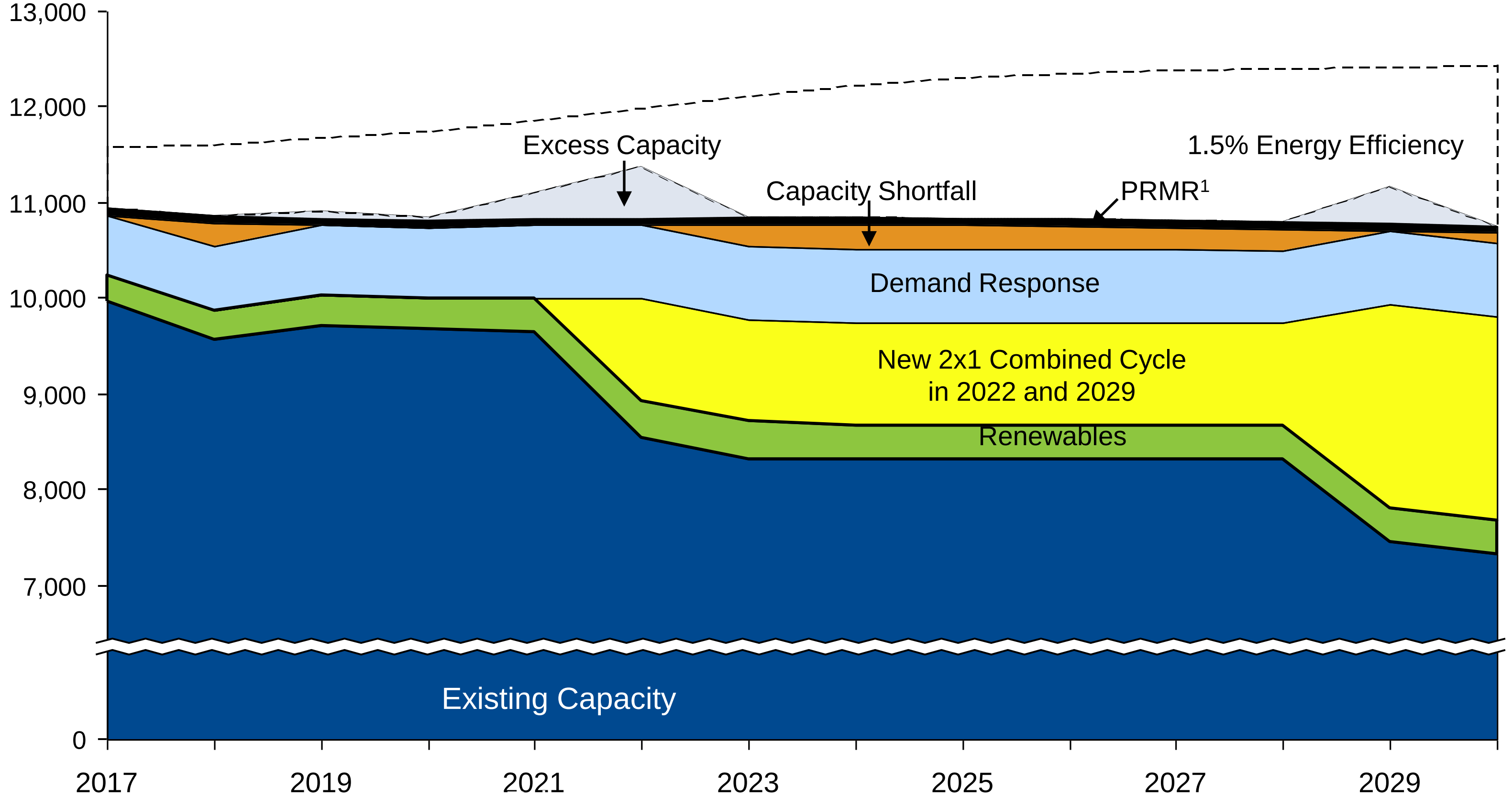
2017 IRP Recommended Long Term Plan (MW)



Certificates of Necessity are being filed for the 2X1 CCGT in 2022

1. Planning Reserve Margin Requirement

The DTE Electric Planning Principles were an overarching goal for the IRP and vital to determination of the recommended plan

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RELIABILITY	Each plan analyzed was required to meet the reliability planning requirements established by MISO
AFFORDABILITY	Affordability was also measured by the yearly impacts to the revenue requirement
CLEAN	Environmental sustainability and low carbon aspirations were all considered as major factors in the determination of the recommended resource portfolio
FLEXIBLE AND BALANCED	The resource plan needs to be flexible, having the ability to adapt to unforeseen changes in the market. Additionally, it must have a well balanced mix of resources so that it is not heavily reliant on the market or one source of generation
COMPLIANT	All resource plans were modeled to be compliant with the 2016 PA 341 section 6(s) requirements as well as environmental regulations
REASONABLE RISK	The Company desires a portfolio that minimizes risks related to commodity pricing, fuel availability, grid reliability, capacity constraints, operational and regulatory

Fulfilling these planning principles required:

- setting proper constraints when modeling
- risk evaluation of the modeling results

DTE Electric utilized two main approaches to Risk Assessment in the 2017 IRP

Stochastic Analysis

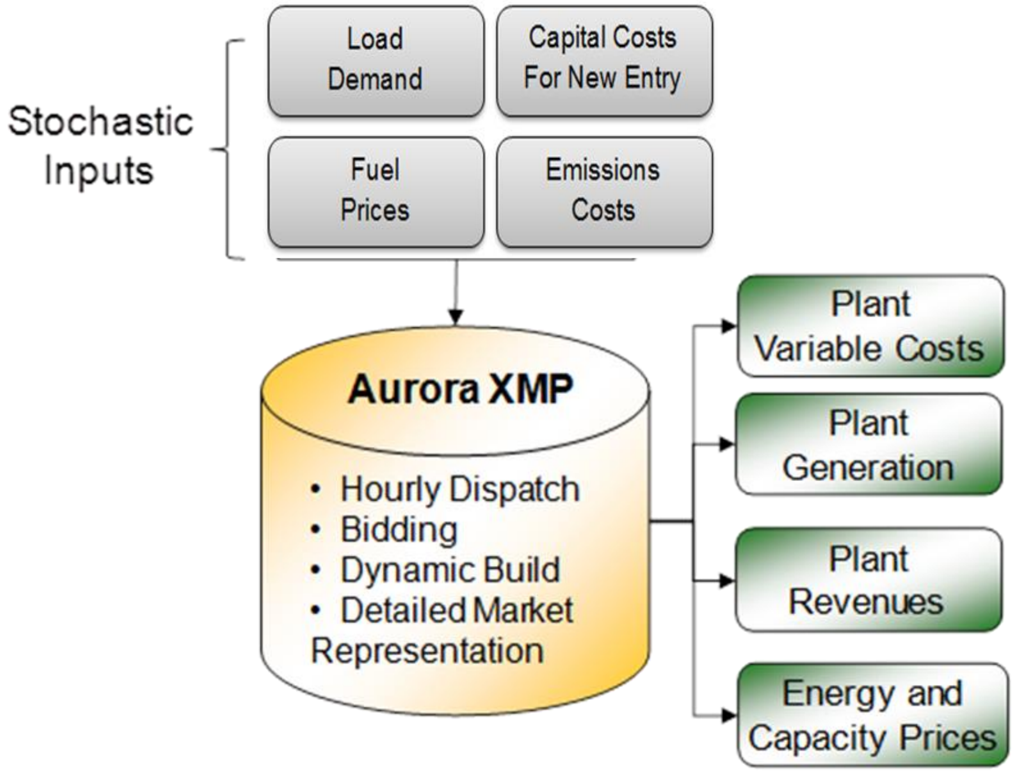
- We completed a stochastic analysis utilizing the EPIS Aurora XMP model[1]. This analysis evaluated our chosen portfolio as well as three other significantly different portfolios over 200 draws of numerous tied assumptions (fuel, capital cost, load, and emissions)
- The results proved that our recommendation of the 1,100 MW combined cycle was robust and had the lowest expected cost and lowest economic risk out of the four portfolios tested

Analytic Hierarchy Process

- This approach is a way to decompose complex problems into a hierarchy of criteria and alternatives. Qualitative judgements of criteria importance and the judged probability of different scenarios playing out are combined with the modeling data to arrive at an optimal solution
- Our recommended portfolio with the 1,100 MW combined cycle was found to be the optimal portfolio using this approach

1. Our modeling consultant, PACE Global completed the Stochastic analysis for us

Stochastic Modeling process



Pace Global uses AURORAxmp® to model hourly dispatch, bidding, dynamic buildouts and detailed market representation.

From the model results, the data can be analyzed to determine portfolio costs and economic risk

The Aurora model in the stochastic mode was run with four different build plans

Four significantly different portfolios were chosen for evaluation in the risk assessments

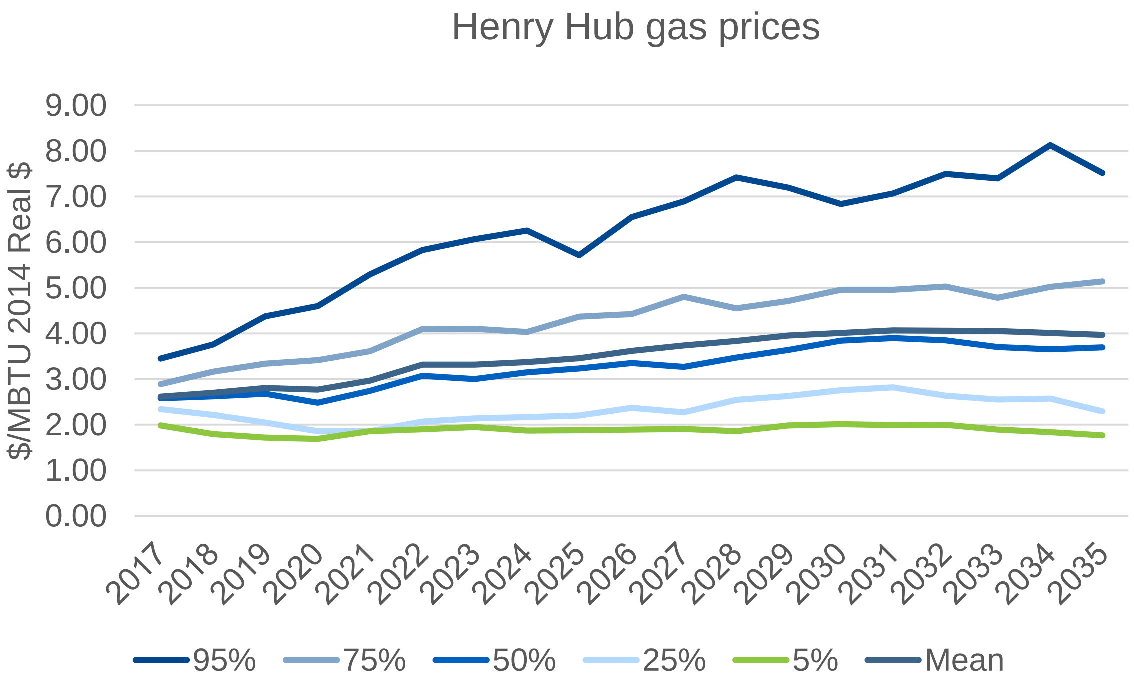
Portfolio	Build
Recommended Build	1,100 MW combined cycle in 2022
Wind	950 MW CT in 2022, 1000 MW wind (2017-2023)
Solar	950 MW CT in 2022, 500 MW solar (2017-2023)
Demand Response	950 MW CT in 2022, 150 MW demand response (2017-2023)

The differences shown are the only differences between the portfolios; retirements and the 2029 CCGT remained the same in all four portfolios, as did the recommended amount of renewables, energy efficiency, and demand response

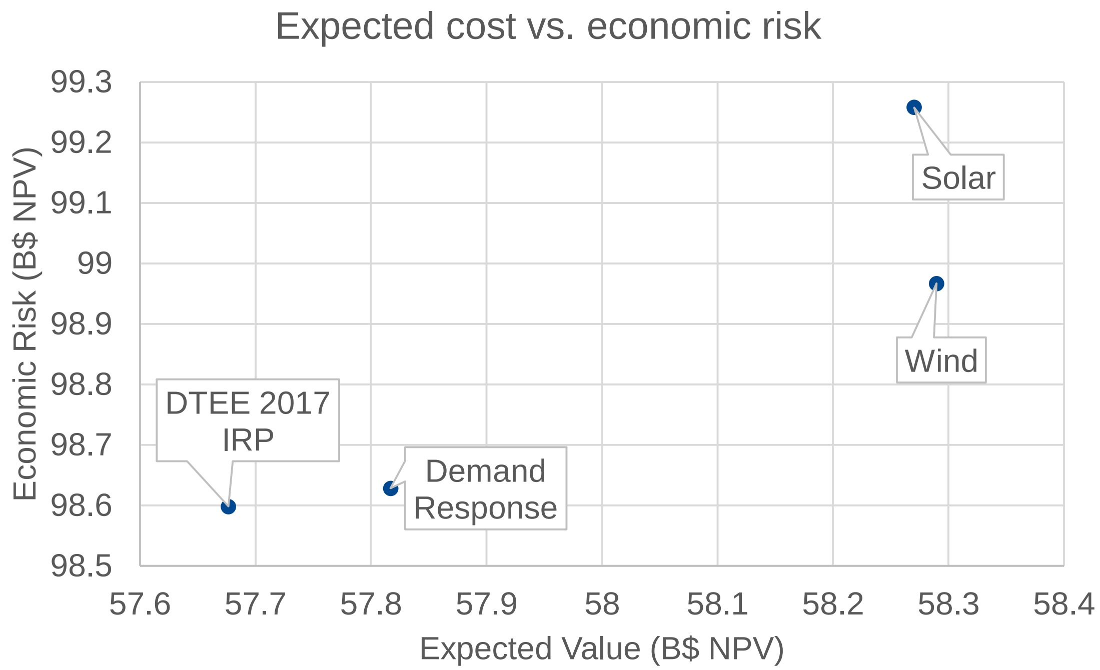
Numerous variables that exhibit volatility and uncertainty were varied across a range of values

200 draws were performed using variations across these variables. Gas prices are shown for an example

- Emissions, SO_2, NO_X, CO_2
- Load forecast
- Gas, coal, and oil prices
- New unit capital costs



The results of the stochastic analysis confirmed that our recommended plan was the lowest risk and had the lowest expected cost



The expected value is the mean fleet cost out of 200 draws

The economic risk takes the average of the top 10% of the costliest draws, or the tail risk

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The criteria for the AHP were developed as a derivation of the DTE Electric Planning Principles

AHP criteria	Metric	Corresponding IRP Planning Principle
Cost	PVRR	Affordability
Environmental	CO_2 tons	Clean
Portfolio Balance	Function of the amount of base load to peaking units added	Flexible and Balanced
Commodity Prices	Weighted average of the fuel volatility index for gas, coal, nuclear, purchases, and renewable	Reasonable risk Flexible and Balanced
Market risk	Net purchases and sales	Reasonable risk

All portfolios analyzed were Reliable and Compliant

The Analytic Hierarchy Process has several steps with an objective to select an optimal IRP portfolio. First, criteria were defined:

Cost: The cost of each portfolio was determined from the Strategist model on an NPV basis. Included in this cost are: capital cost of new builds, O&M of new builds, fuel of the fleet, and market purchases and sales. In other words, any differences in costs between the portfolios is captured in this cost number

Environmental Impacts: CO_2 emission differences between the portfolios are captured over the entire study period. CO_2 was determined to be the dominant environmental consideration over the different portfolios

Portfolio Balance: This metric is used to capture differences between the types of generation added to the fleet. Effects of baseload vs. peaking type units are brought out in this metric

Commodity Price risk: Trying to achieve good fuel diversity; spreading the fuel types across many different types is preferred, including the “free” renewable fuel[1] and market purchases. The fuel by MBTU required by the portfolio was extracted from the model. Then a weighted average of the fleet MBTU by the volatility of the fuels – gas, coal, oil, market purchases was determined

Energy Risk: The net purchases and sales over the study period is tracked. Since there are risks to depending too much on the market – both for sales and purchases, the closer to zero net purchases is preferred for this criteria

1. Renewables and Market purchases were given a “heat rate” for 10,000 Mbtu/kWh for calculation purposes

Then, ranking the priorities of the criteria is done with a pairwise matrix by subject matter experts

Criteria 1	Criteria 2	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average score
Cost	Environmental						
Cost	Portfolio Balance						
Cost	Commodity Prices						
Cost	Energy Risk						
Environmental	Portfolio Balance						
Environmental	Commodity Prices						
Environmental	Energy Risk						
Portfolio Balance	Commodity Prices						
Portfolio Balance	Energy Risk						
Commodity Prices	Energy Risk						

Intensity of Importance	Definition	Explanation
9	Extreme Importance	The evidence favoring Criteria 1 over Criteria 2 is of the highest possible order of affirmation
7	Very Strong Importance	Criteria 1 is strongly favored over Criteria 2; its dominance is demonstrated in practice
5	Strong Importance	Experience and judgment strongly favor Criteria 1 over Criteria 2
3	Moderate Importance	Experience and judgment slightly favor Criteria 1 over Criteria 2
1	Equal Importance	The two criteria contribute equally to the objective
0.33	Moderate Importance	Experience and judgment slightly favor Criteria 2 over Criteria 1
0.20	Strong Importance	Experience and judgment strongly favor Criteria 2 over Criteria 1

(and reciprocals of 7, 9)

The scenarios were then rated against each other in a pairwise matrix using a similar rating scale

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Scenario 1	Scenario 2	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average score
Reference	High Gas						
Reference	Low Gas						
Reference	Emerging Tech.						
Reference	Aggressive CO_2						
High Gas	Low Gas						
High Gas	Emerging Tech.						
High Gas	Aggressive CO_2						
Low Gas	Emerging Tech.						
Low Gas	Aggressive CO_2						
Emerging Technology	Aggressive CO_2						

Intensity of likelihood	Definition	Explanation
9	Extreme likelihood	The evidence favoring scenario 1 over scenario 2 is of the highest possible order of affirmation
7	Very Strong likelihood	Scenario 1 is strongly favored over scenario 2; its dominance is demonstrated in practice
5	Strong likelihood	Experience and judgment strongly favor scenario 1 over scenario 2
3	Moderately more likely	Experience and judgment slightly favor scenario 1 over scenario 2
1	Equally likely	Two scenarios equally likely to occur
0.33	Moderately less likely	Experience and judgment slightly favor scenario 2 over scenario 1
0.20	Strongly less likely	Experience and judgment strongly favor scenario 2 over scenario 1

(and reciprocals of 7, 9)

Four build plans were analyzed across eight scenarios and sensitivities

Four significantly different portfolios were chosen for evaluation in the risk assessments

Portfolio	Build
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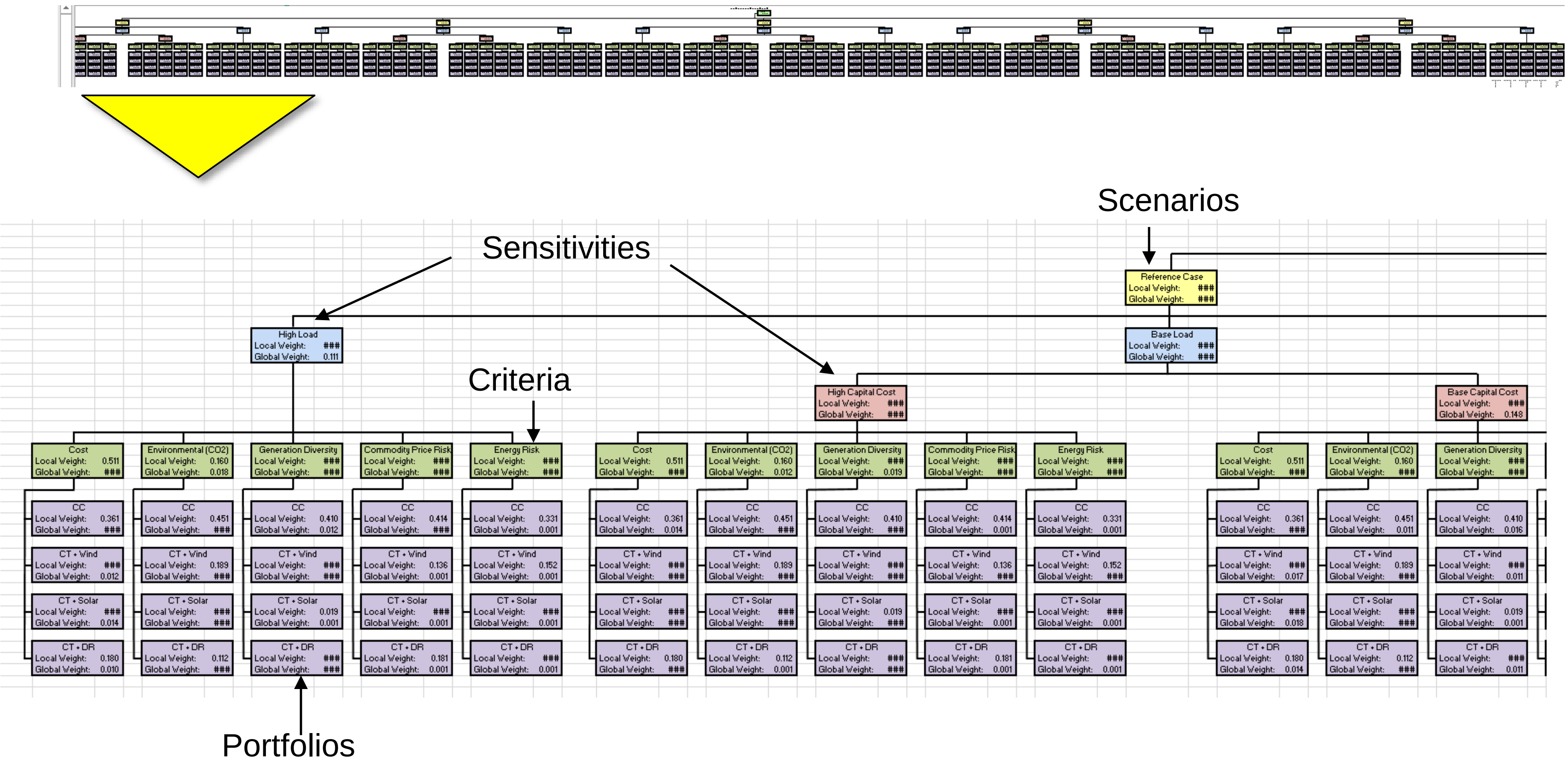
Demand Response	950 MW CT in 2022, 150 MW Demand Response (2017-2023)

The three sensitivities evaluated included:

- High Load
- Low Load
- High Capital Cost

After the pairwise matrices are completed, the data is synthesized using a computational tree in Excel



The Excel tool combines the pairwise judgements and the modeling output metrics to compute the optimal decision

The excel tool combines:

- The pair-wise judgements of the likelihood of portfolios
- The pair-wise judgements of the importance of the criteria

With

- The extracted criteria metric outputs for the five criteria over five scenarios and three sensitivities

To arrive at an optimal decision

The optimal portfolio has the highest score from the computation

Alternative	Score
CCGT	0.402
CT + Wind	0.235
CT + Solar	0.160
CT + DR	0.203

The risk analysis completed on the 2017 DTE IRP confirms that the recommendation is robust and prudent

Risk Analysis	Results	Supportive of DTEE IRP?
Stochastics	The 2022 CCGT portfolio had the lowest expected cost and economic risk	✓
Analytical Hierarchy Process	The 2022 CCGT portfolio had the optimal score when qualitative judgements and quantitative portfolio criteria metrics were combined	✓