

Multi-Criteria Decision Analysis Decision Support in the SMPL/NZP Tool

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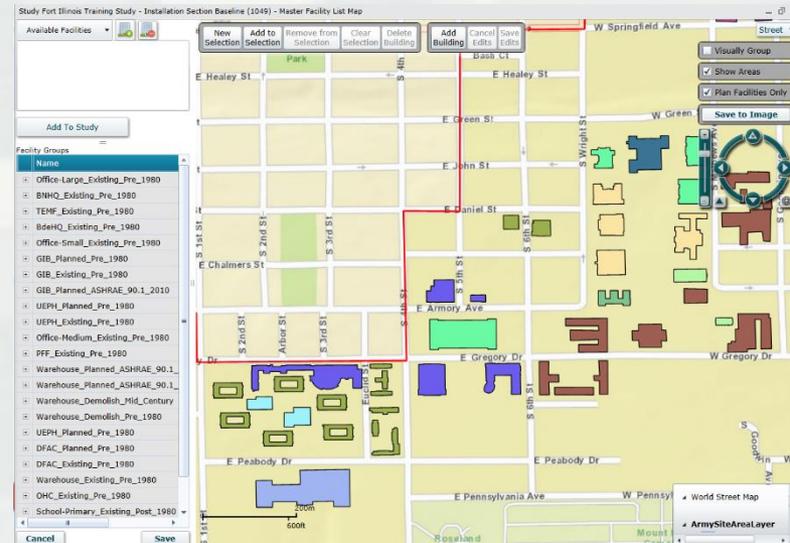


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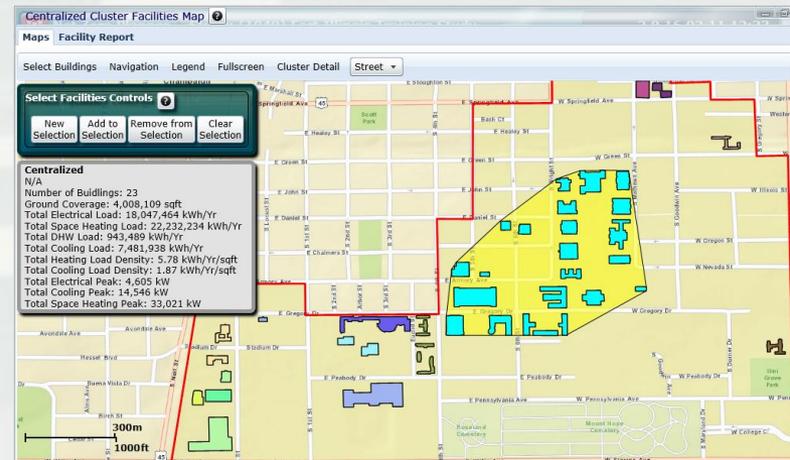
**Distribution Statement A - Approved for public release;
distribution is unlimited.**

SMPL/NZP Tool - reminder

- Web based tool that assists in installation-wide energy and water planning.
- Estimates current and future energy and water **loads and profiles**
- Optimizes **supply side** to meet loads
 - ▶ Electrical integrated with thermal
 - ▶ Resilience
- Estimates costs and returns for ROI analysis



Master Facility Map



Energy Cluster View

Alternative Scenarios

- **Baseline** – A snapshot of the current energy and water use situation. The baseline is one reference point used to evaluate alternative futures.
- **Base Case** – This scenario extends the baseline into the future and includes already-funded renovation as well as planned construction and demolition activities. The base case is a future reference point for “business as usual.”
- **Alternative(s)** – A selected set of scenarios that include different energy and water measures related to buildings, distribution systems, and generation systems. These scenarios are compared to the baseline for energy and water use change and to the Base Case for investment and operational costs.

Facility Load Analysis

Reduce Loads as Much as Economically Feasible

Despite facility area increase of 44%:

- EUI and total energy use decreased by 43%
- Requires additional investment of ~\$72M
- Annualized cost decreased by 20%

Net Zero Planner Study: (1055) Fort Illinois Example 2.0.16.03.11 12:33

Study List Study Information **Facility Loads** Installation or Subsection Decision Analysis Generate Reports Case, Mike

Details Input Simulation Package Selection **Results**

Instructions Based On Comparison %: Baseline

Alternative	Facilities	Total Area ft ²	Site Electricity kBtu	Site Electricity Intensity kBtu/ft ²
Baseline	53	3,173,130	157653520.22	49.68
Future Base Case	65	4,570,489	219476983.22	48.02
High Efficiency Buildings	65	4,570,489	145176239.89	31.76

Reports & Filters

- Cost Optimization Curve
- Debug Report
- Demand By End Use
- Demand Intensity By End Use
- Energy By End Use
- Energy Intensity By End Use

Alternative	Facilities	Total Area ft ²	Site Electricity kBtu	Site Electricity Intensity kBtu/ft ²	Site Electricity Reduction %	Site Gas kBtu	Site Gas Intensity kBtu/ft ²	Site Gas Reduction %	Energy Cost \$/year	Site Total Energy Intensity kBtu/ft ²	Total Bldg Investment Cost \$	Annualized Cost (Energy + Bldg Invest)/(\$/yr)	Total Site Total Energy kBtu
Baseline	53	3,173,130	157,653,520	49.7	0.0	239,651,549	75.5	0	6,382,882	125.2	0	6,382,882	397,305,069
Future Base Case	65	4,570,489	219,476,983	48.0	-39.2	320,381,506	70.1	-33.7	8,788,496	118.1	0	8,788,496	539,858,489
High Efficiency Buildings	65	4,570,489	145,176,240	31.8	7.9	160,893,689	35.2	32.9	5,438,078	67.0	71,861,472	6,999,506	306,069,929

investment

life cycle cost decreases

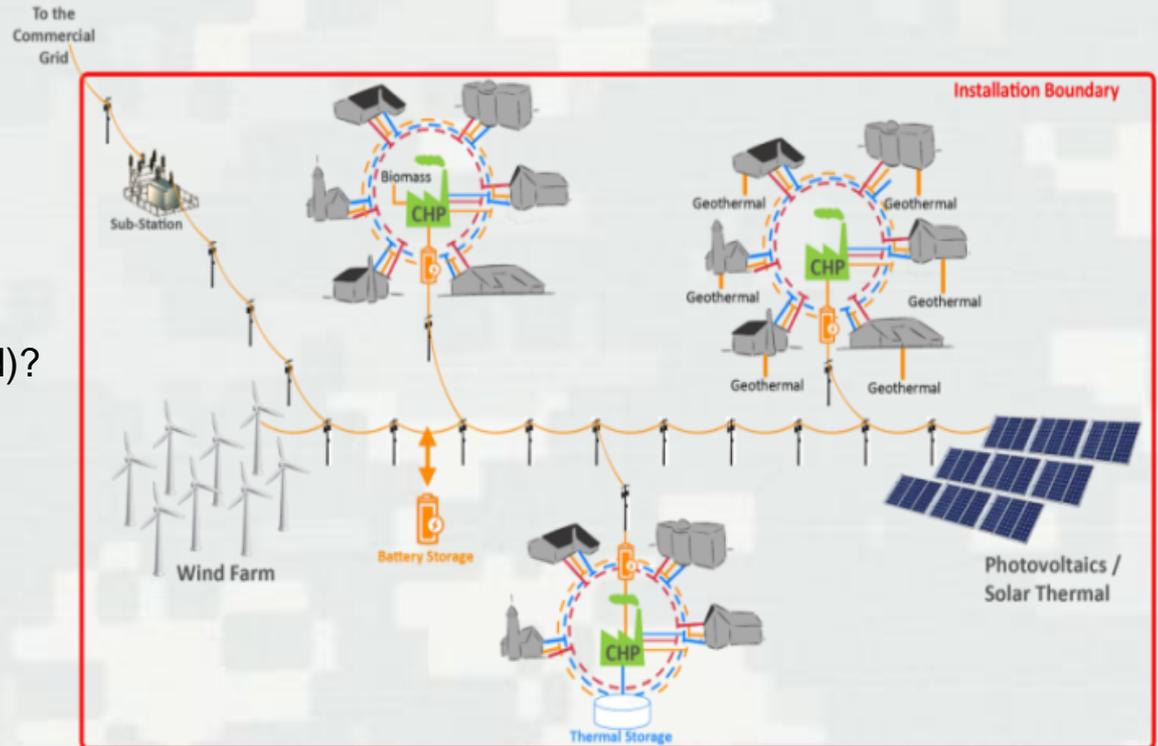
energy use decreases

Optimize Supply and Distribution

Loads were determined in the previous section

What is the most cost effective way to meet those loads?

- How long can the community run using on-site generation?
- Distribution
 - ▶ Electrical Power Grid?
 - ▶ Decentralized Heating/Cooling (Natural Gas Grid)?
 - ▶ District Heating/Cooling?
- Storage
 - ▶ Thermal
 - ▶ Electrical
- Supply
 - ▶ Renewables?
 - Solar
 - Wind
 - Biomass
 - Etc.
 - ▶ Fossil Fuels?



Decision Support Example

This is enough to
make a decision -
right?

Scenarios	SI Units NZP Energy (MWh/yr)							
	Total Fossil Fuel + Biomass Fuel	Total Electricity	Total Site Energy	Total Source Energy	% Source Reduction from Baseline	Investment \$	Life Cycle Cost (Disc Rate = 3%)	Simple Payback Yrs
Baseline	258,810	23,228	282,038	348,550	0%			
Basecase	259,424	31,020	290,444	375,219	-8%		\$477,361,000	
District Steam	196,254	14,488	210,742	253,866	27%	\$155,220,000	\$460,051,000	25
District Hot Water	188,011	16,189	204,200	250,916	28%	\$144,570,000	\$435,313,000	21
Decentralized	45,564	78,232	123,796	308,998	11%	\$141,240,000	\$467,827,000	27
Net Zero Fossil Fuel	2,828 /303,132	2,297	307,957	40,628	88%	\$193,155,480	\$562,650,000	* See Note

SMPL/NZP Quantitative Output

- For each alternative:
 - ▶ First cost, annual costs
 - ▶ Energy and water consumed
 - ▶ Costs of energy and water
 - ▶ On-site generation capacity
 - ▶ Many more values that could be used as metrics

How much do we care about each of these metrics?

What if you have a lot of metrics?



Multi-Criteria Decision Analysis

“Multi-criteria decision analysis (MCDA) is a sub-discipline of operations research that explicitly evaluates multiple conflicting criteria in decision making.”*

- E.g. – Cost versus energy efficiency... or resilience



*https://en.wikipedia.org/wiki/Multiple-criteria_decision_analysis



SMPL/NZP supports one or more MCDA Models

enu

Decision Analysis - MCDA Models

Select All

Deselect All

Create a New MCDA Model

User Defined Metrics



« ‹ › »

Page 1 of 1

Calculate

Economic Model Only

View

Delete

Created: Schueckler, Jill M (4/5/2017 4:07 PM)

Modified: Liesen, Richard (4/6/2017 9:58 AM)

Access Level: Edit Model Structure, Value Functions and Weights

Calculate

Energy and Economics

View

Delete

Created: Schueckler, Jill M (4/5/2017 4:11 PM)

Modified: Liesen, Richard (4/6/2017 10:02 AM)

Access Level: Edit Model Structure, Value Functions and Weights

Calculate

Stakeholder Model

View

Delete

Created: Schueckler, Jill M (4/5/2017 3:55 PM)

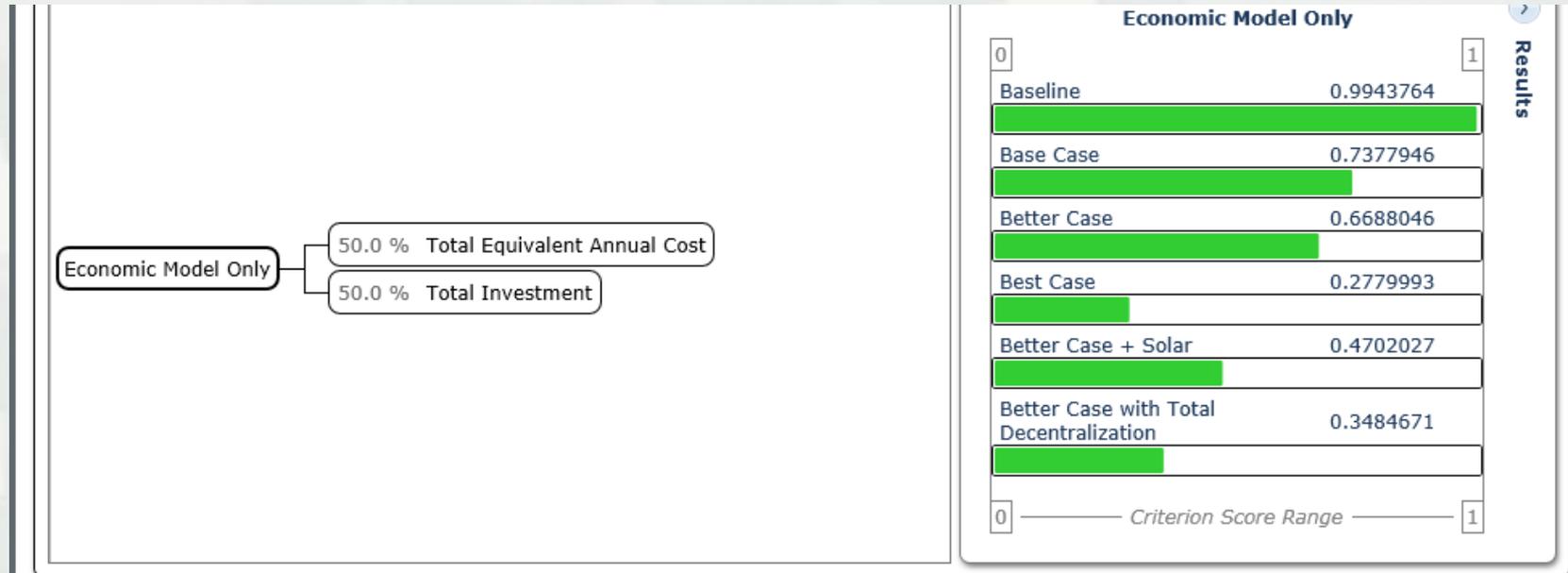
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Access Level: Edit Model Structure, Value Functions and Weights



A Model Consists of Weighted Metrics

E.G. - Economics Only

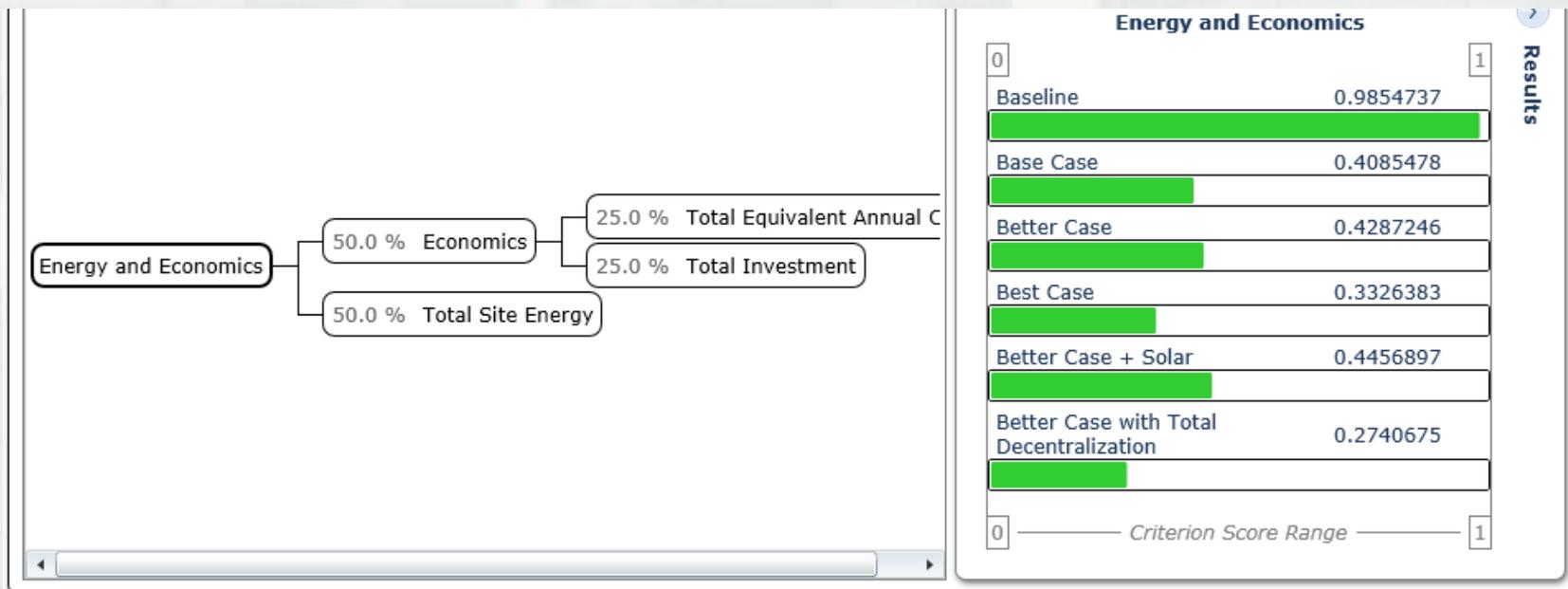


Input Data

Metrics \ Alternatives	Number of Facilities	Total Square Footage	Total Investment	Building Investment	Cluster Investment	Total Equivalent Annual Cost
	#	ft ²	Dollars	Dollars	Dollars	Dollars/Year
Baseline	215	3383022	0	0	0	3134968
Base Case	189	5528632	21186124	0	21186124	9115012
Better Case	189	5528632	34289800	13491292	20798510	8805220
Best Case	189	5528632	94530752	74642616	19888140	9148404
Better Case + Solar	189	5528632	64516056	13525902	50990152	9037727
Better Case with Total Decentralization	189	5528632	56459764	13602395	42857368	13167825

* The underlined text is a name of user defined metric

Consider Cost versus Performance



Input Data

Alternatives	Metrics	Number of Facilities	Total Square Footage	Total Investment	Building Investment	Cluster Investment	Total Equivalent Annual Cost
		#	ft ²	Dollars	Dollars	Dollars	Dollars/Year
Baseline		215	3383022	0	0	0	3134968
Base Case		189	5528632	21186124	0	21186124	9115012
Better Case		189	5528632	34289800	13491292	20798510	8805220
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Qualitative Metrics

- Add Community Sentiment as a qualitative metric

Properties

Sensitivity Analysis

Rename

Move Up

Cut

Delete

Paste as a Sub Criterion

Add New

Move Down

Copy

Paste

* Display Local Weights
 Highlight Errors

```

            graph LR
            A[Energy and Economics 33.3%] --- B[Economics 33.3%]
            A --- C[Total Site Energy 33.3%]
            A --- D[Community Sentiment 33.3%]
            B --- E[Total Equivalent Annual C 16.7%]
            B --- F[Total Investment 16.7%]
            
```

Energy and Economics

0		1
Baseline	N/A	
Base Case	N/A	
Better Case	N/A	
Best Case	N/A	
Better Case + Solar	N/A	
Better Case with Total Decentralization	N/A	
0	Criterion Score Range	1

Metric for Community Sentiment

Large solar field might interfere
with view shed

Metric: **Viewshed**

[Create New Metric](#)

[Delete](#)

Metric Details

Name:

Viewshed

Unit:

rating

Default Value:

5

Description:

Reaction of the community to renewable equipment

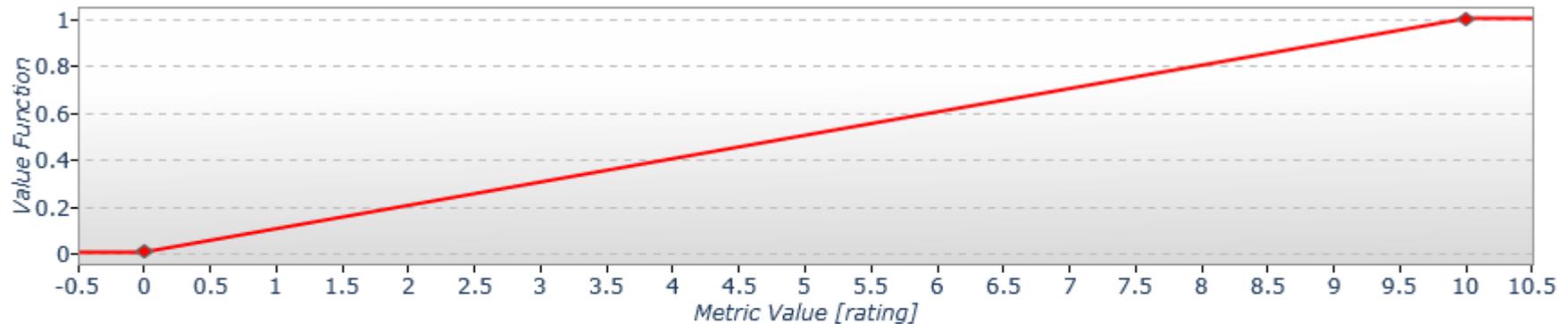
Metric Data

Alternative Name	Value
Baseline	5
Base Case	5
Better Case	5
Best Case	5
Better Case + Solar	2
Better Case with Total Decentralization	5

Create Value Function for the Community Sentiment Metric

- Use view shed rating to represent community sentiment
- Rated on scale of 0 – 10. 0 is bad, 10 is good.
- Map to a value between 0 and 1

Value Function



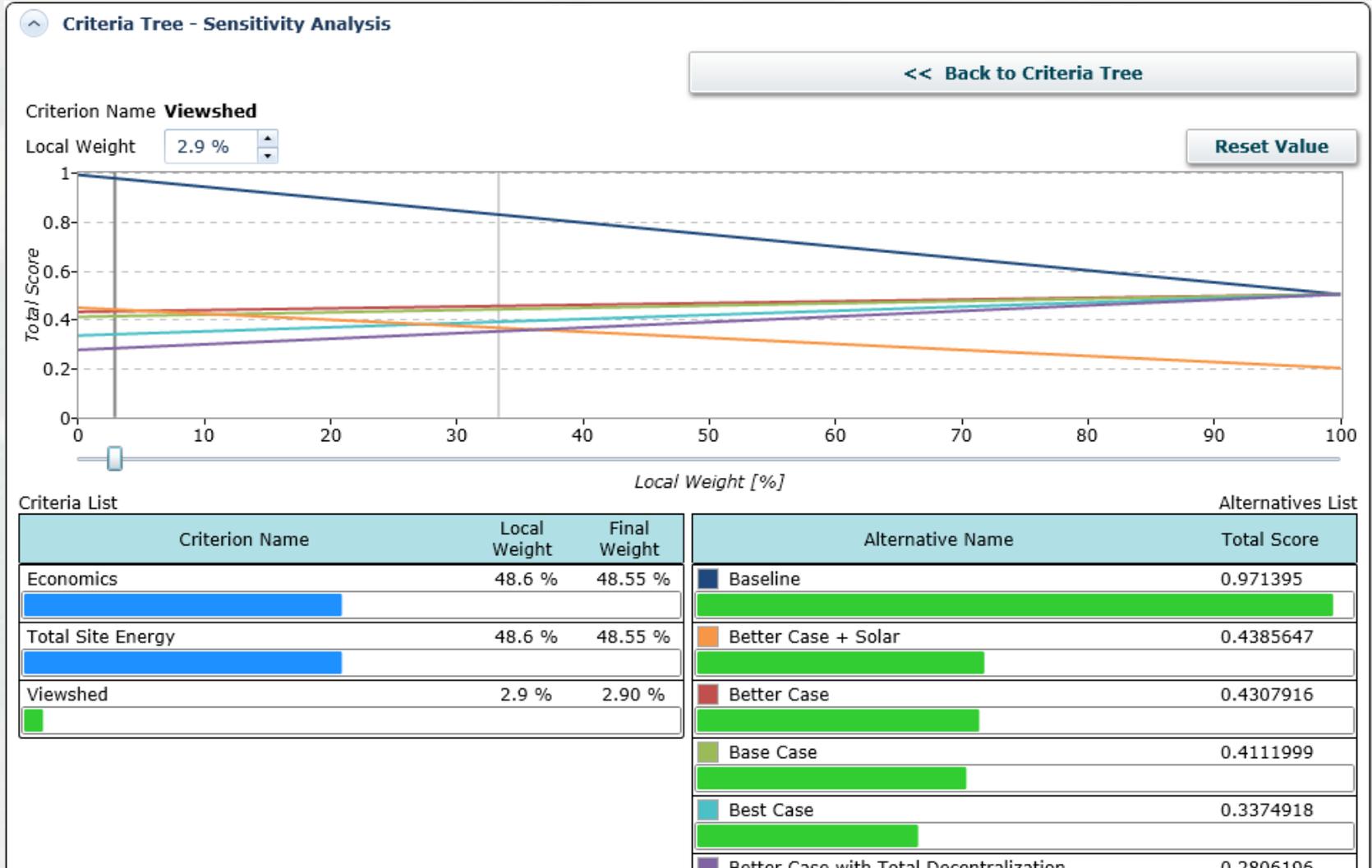
Templ

Add Ne

	Metric Value	Value Function	Options
	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="checkbox"/> Discontinuity
	<input type="text" value="10"/>	<input type="text" value="1"/>	<input type="checkbox"/> Discontinuity

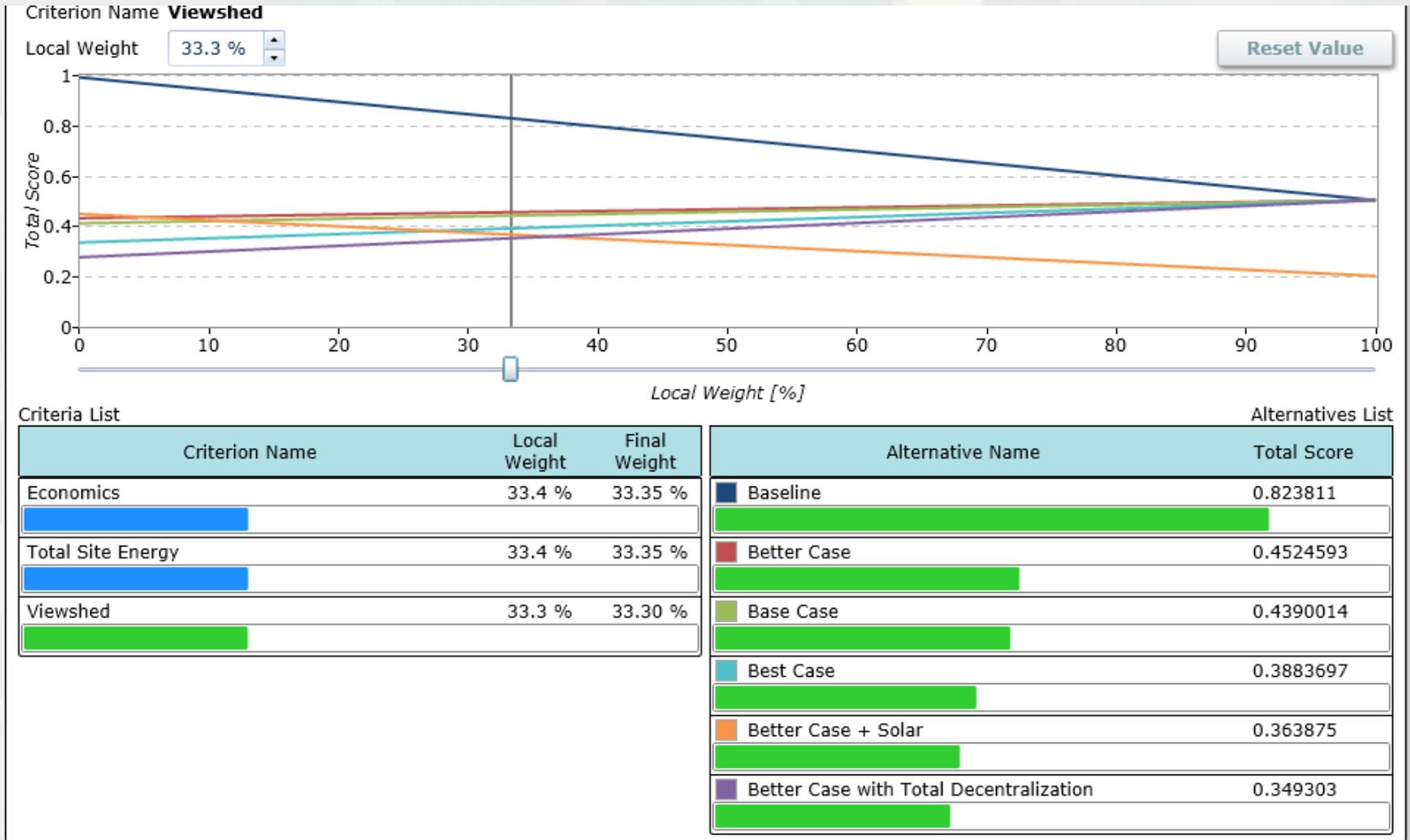
Sensitivity Analysis

Low weight on view shed



Sensitivity Analysis

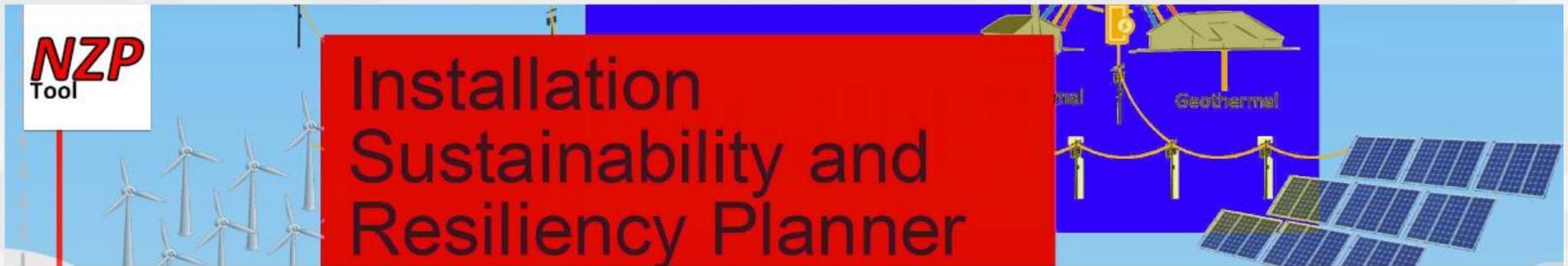
Higher weight on view shed



SMPL-NZP Tool Training Videos available on YouTube

<https://www.youtube.com/channel/UC2sdFPLVc5TENXyuRL4SzNw>

Search for “NZP Tool” in YouTube



SMPL-NZP Tool Training and Tech Manual

Master Planning Training Courses Developed (DOD Master Planning Institute/PROSPECT)

Course 258: Master Planning Energy and Sustainability addressing the SCP/ process

Next offering: 13-16 March 2018, New Orleans, LA

Course 163: Master Planning Sustainability and Resilience addressing how to use SMPL/NZP Modeling Tool to assess different Energy, water, and waste

Next offering: 24-26 April 2018, Champaign, IL

There is a Pre-Final version SCP/ Technical Manual

Conclusions

- Not enough to have metrics alone
- MCDA offers a means to capture how much weight Stakeholder assign to different metrics
- The SMPL/NZP Tool supports quantitative and qualitative metrics in a MCDA tool



Questions?

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