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

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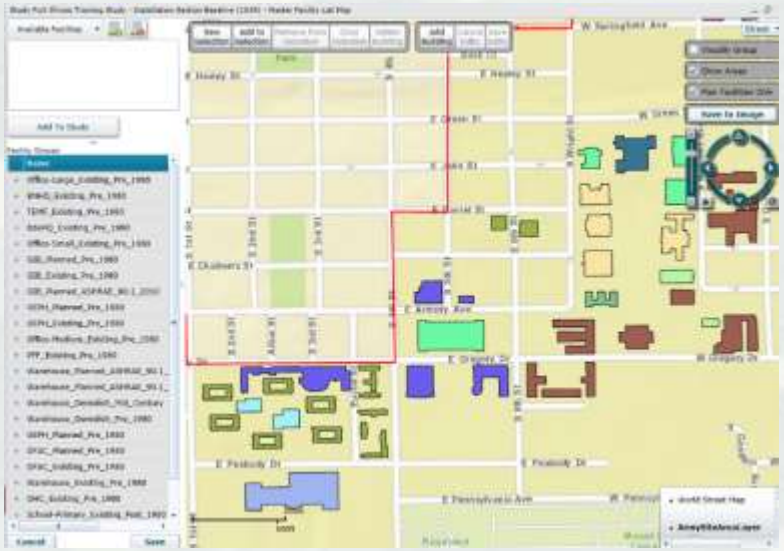
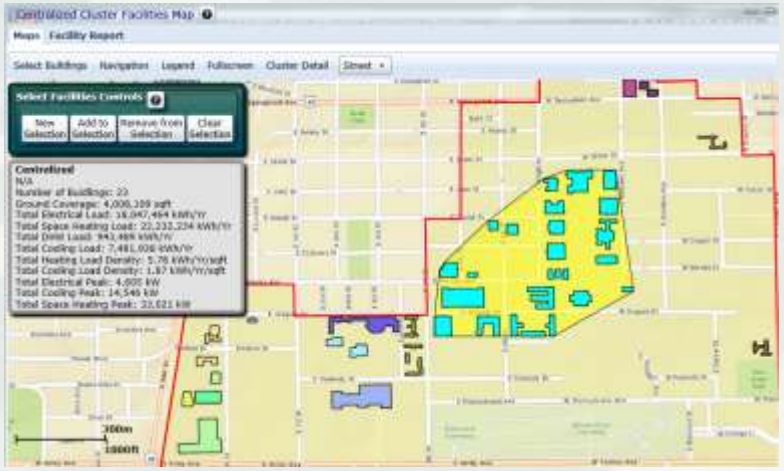
SMPL/NZP Tool - reminder

- 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.

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%

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 $	Total Annualized Cost (Energy + Bldg Invest)($/yr)	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

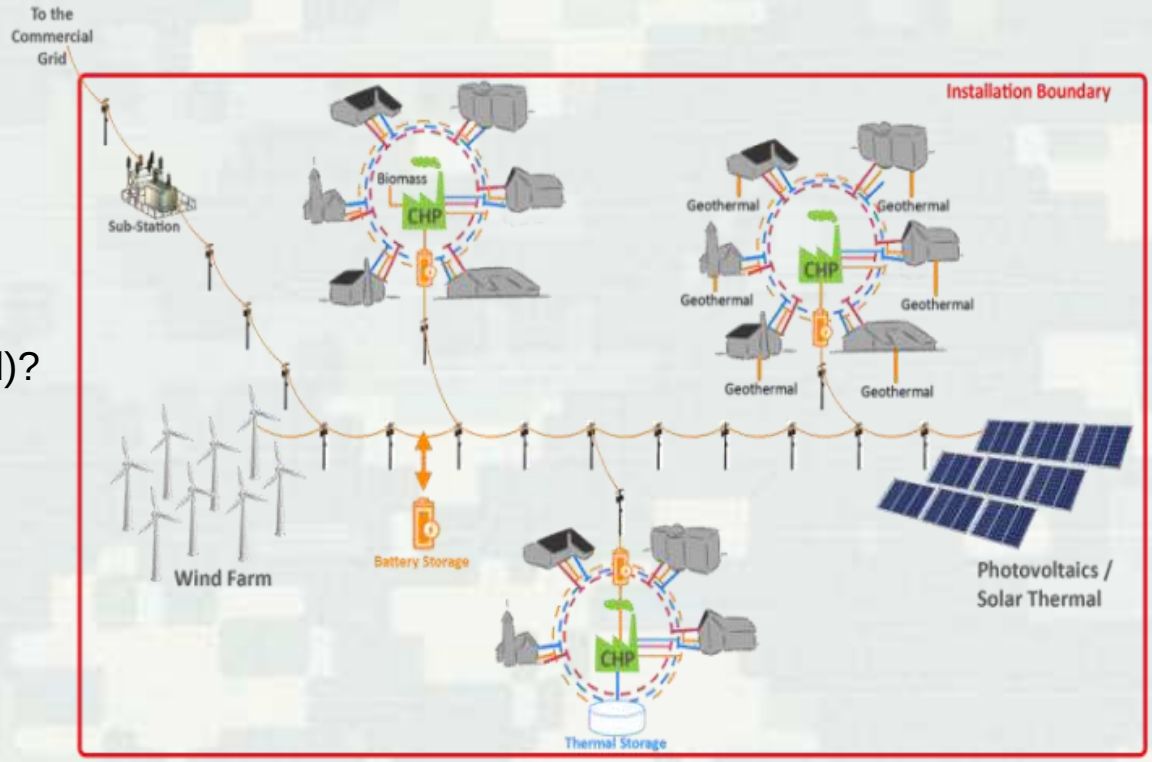
Optimize Supply and Distribution

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?

	SI Units NZP Energy (MWh/yr)							
Scenarios	**Total Fossil Fuel + Biomass Fuel**	**Total Electricity**	**Total Site Energy**	**Total Source Energy**	**% Source Energy 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 alterative:
  - 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?

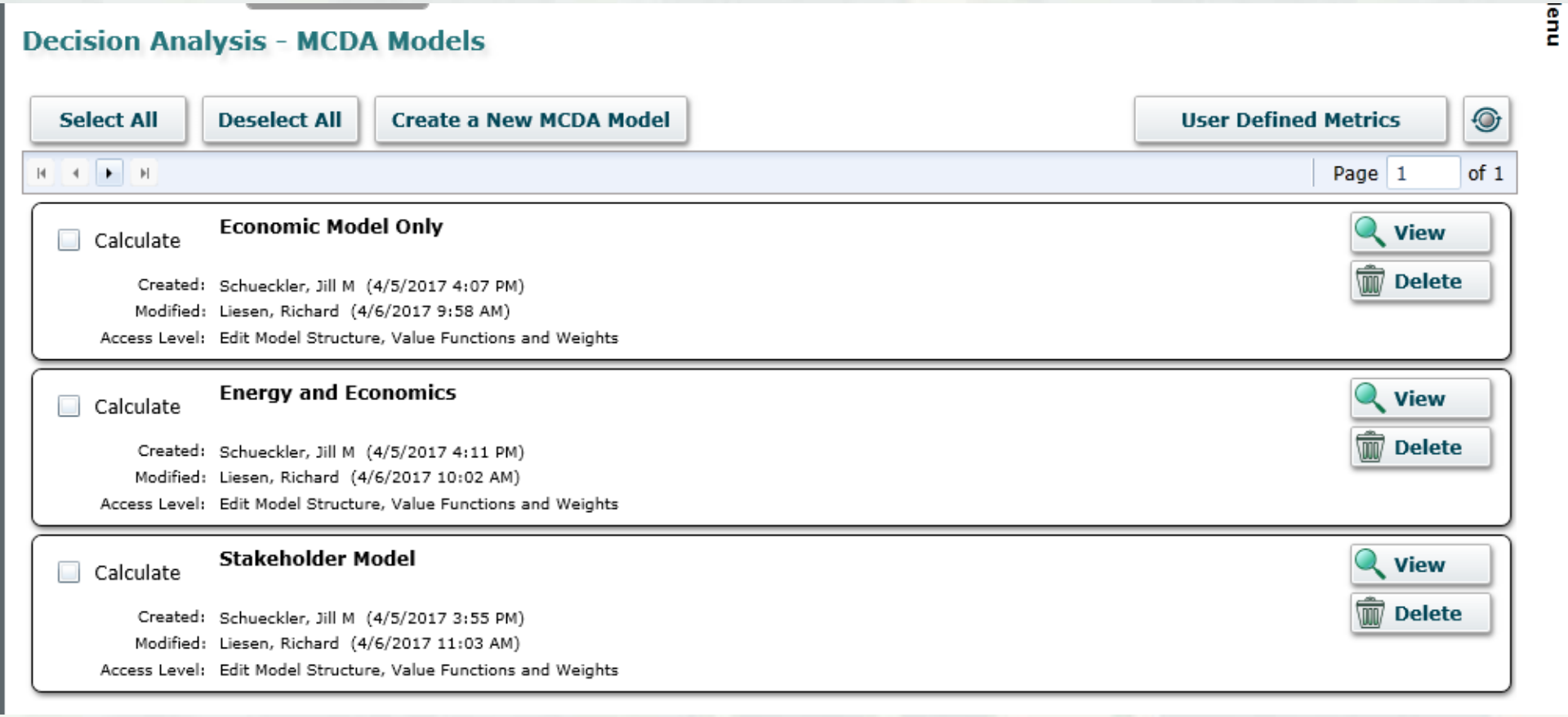
Multi-Criteria Decision Analysis

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

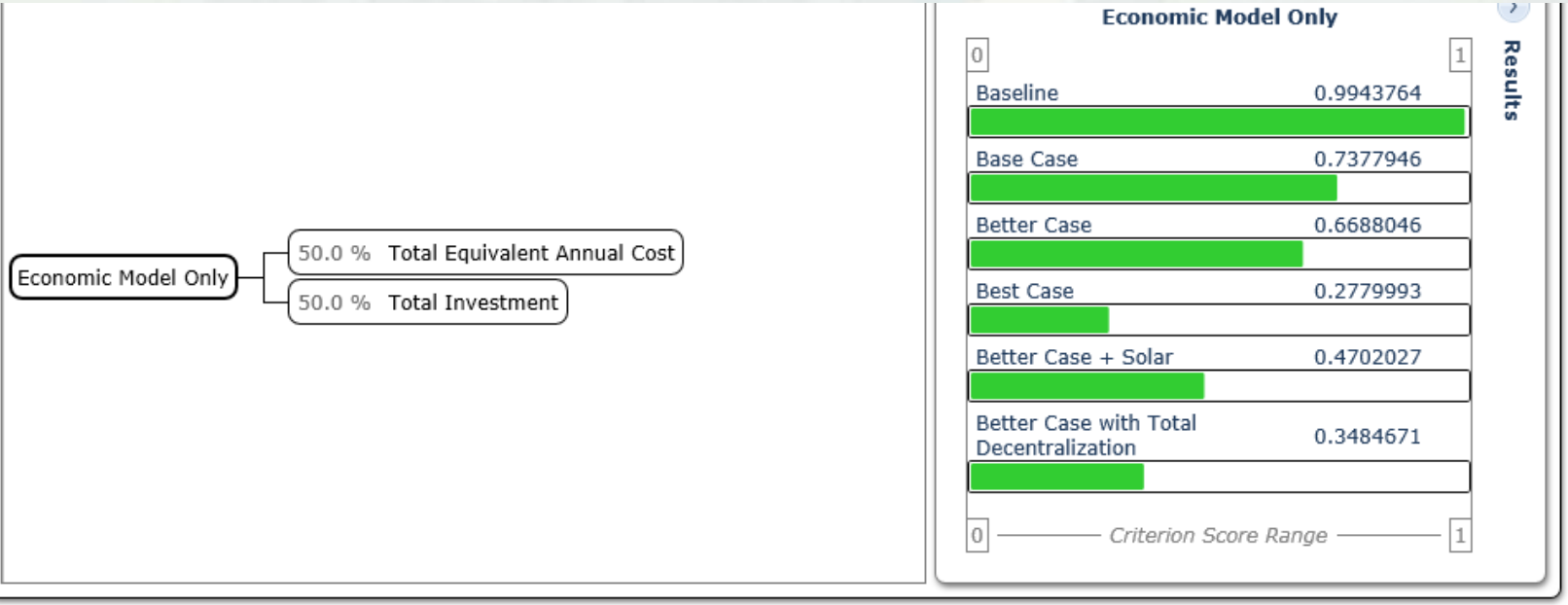
- E.g. – Cost versus energy efficiency… or resilience

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

SMPL/NZP supports one or more MCDA Models



A Model Consists of Weighted Metrics E.G. - Economics Only

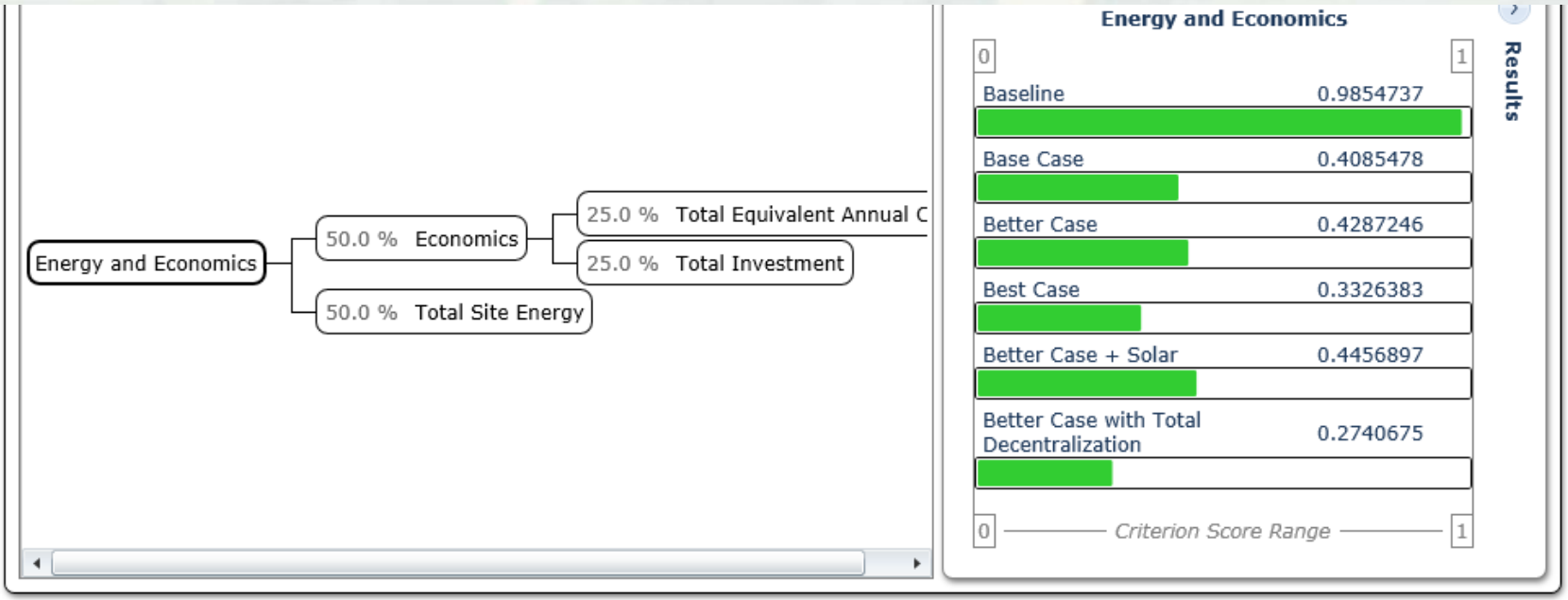


Input Data

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



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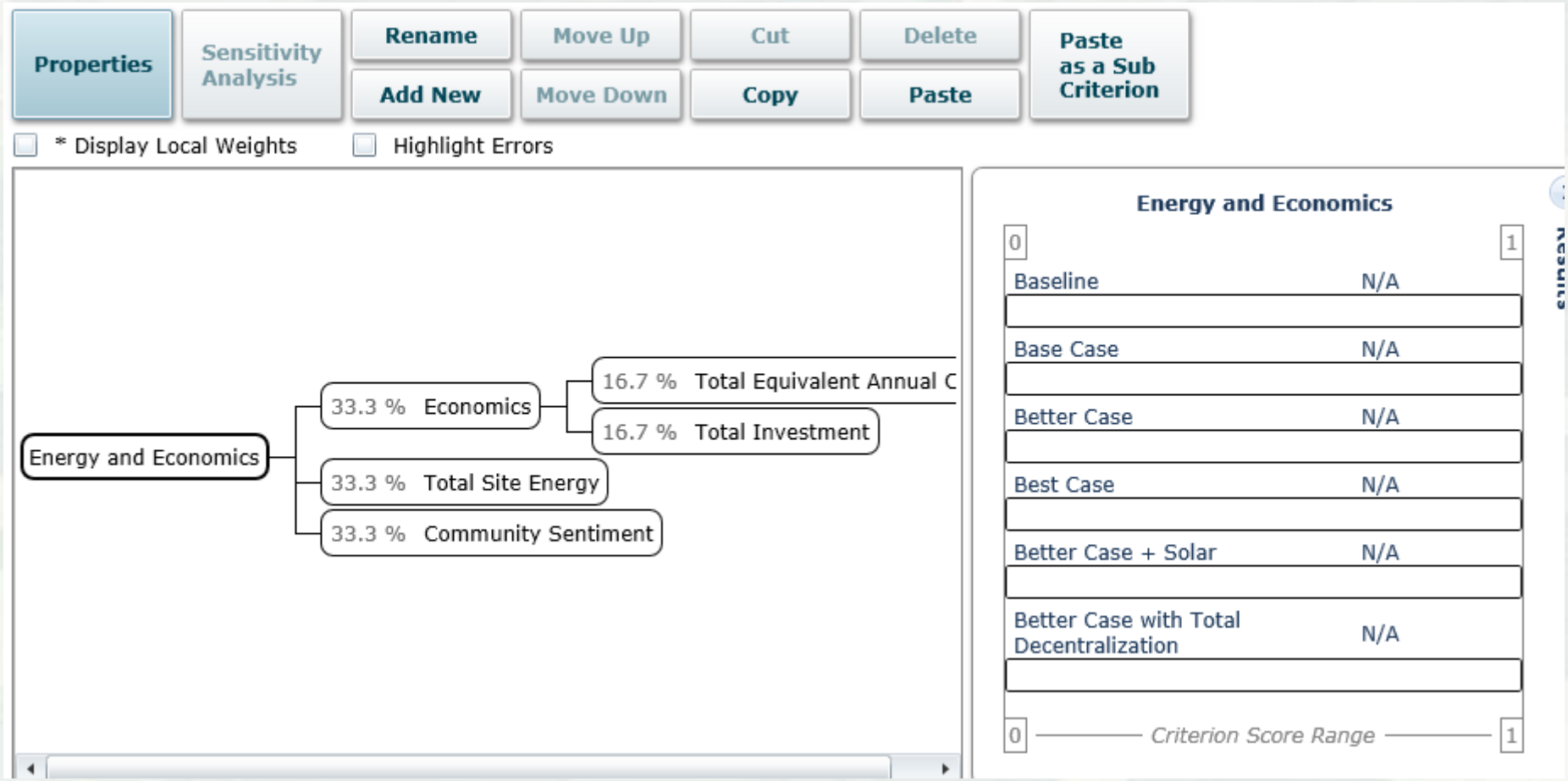
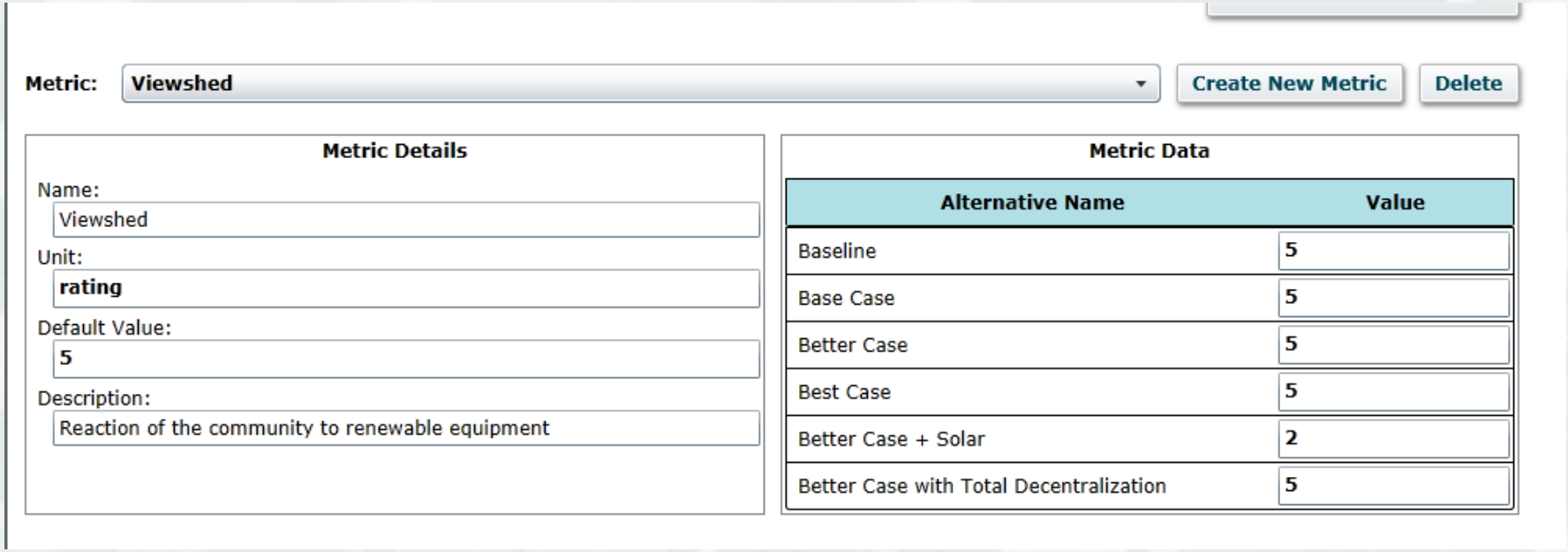
Qualitative Metrics

- Add Community Sentiment as a qualitative metric



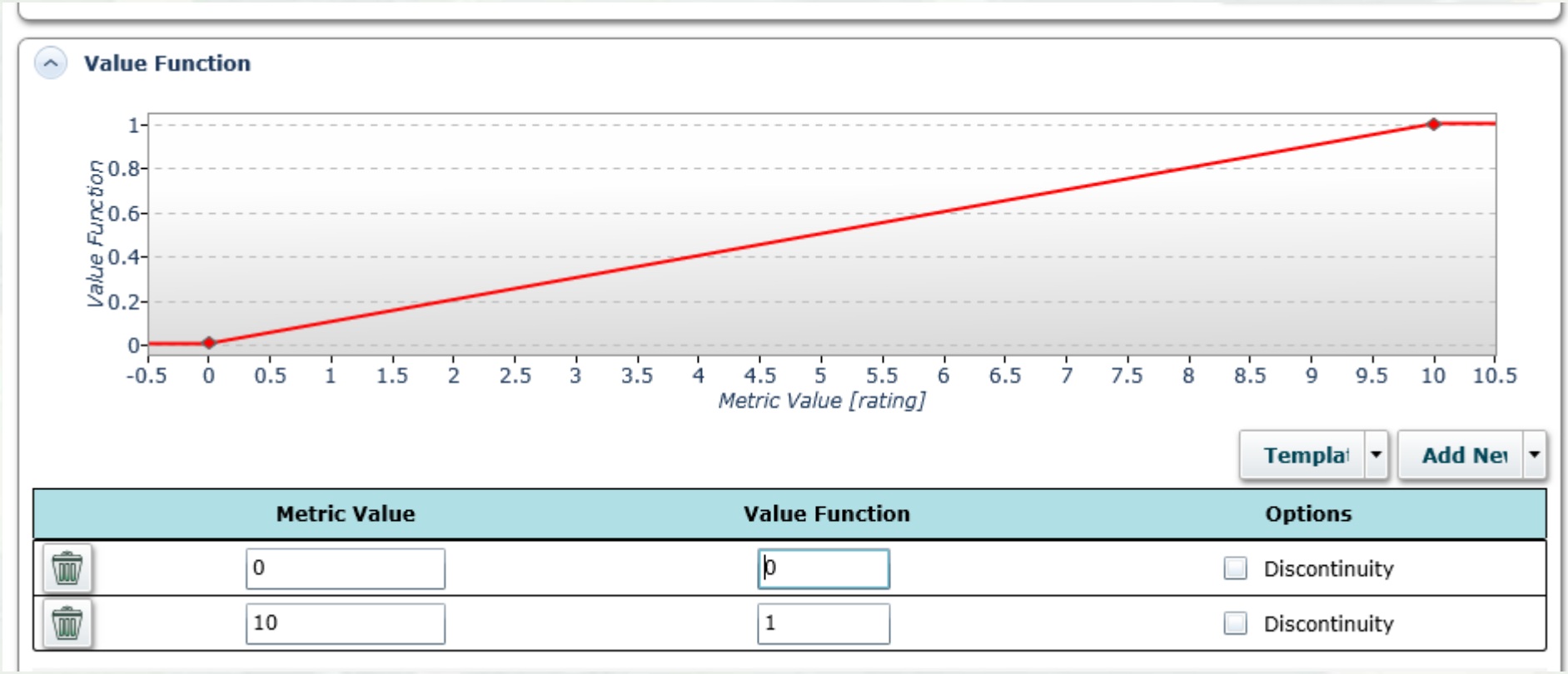
Metric for Community Sentiment

Large solar field might interfere with view shed

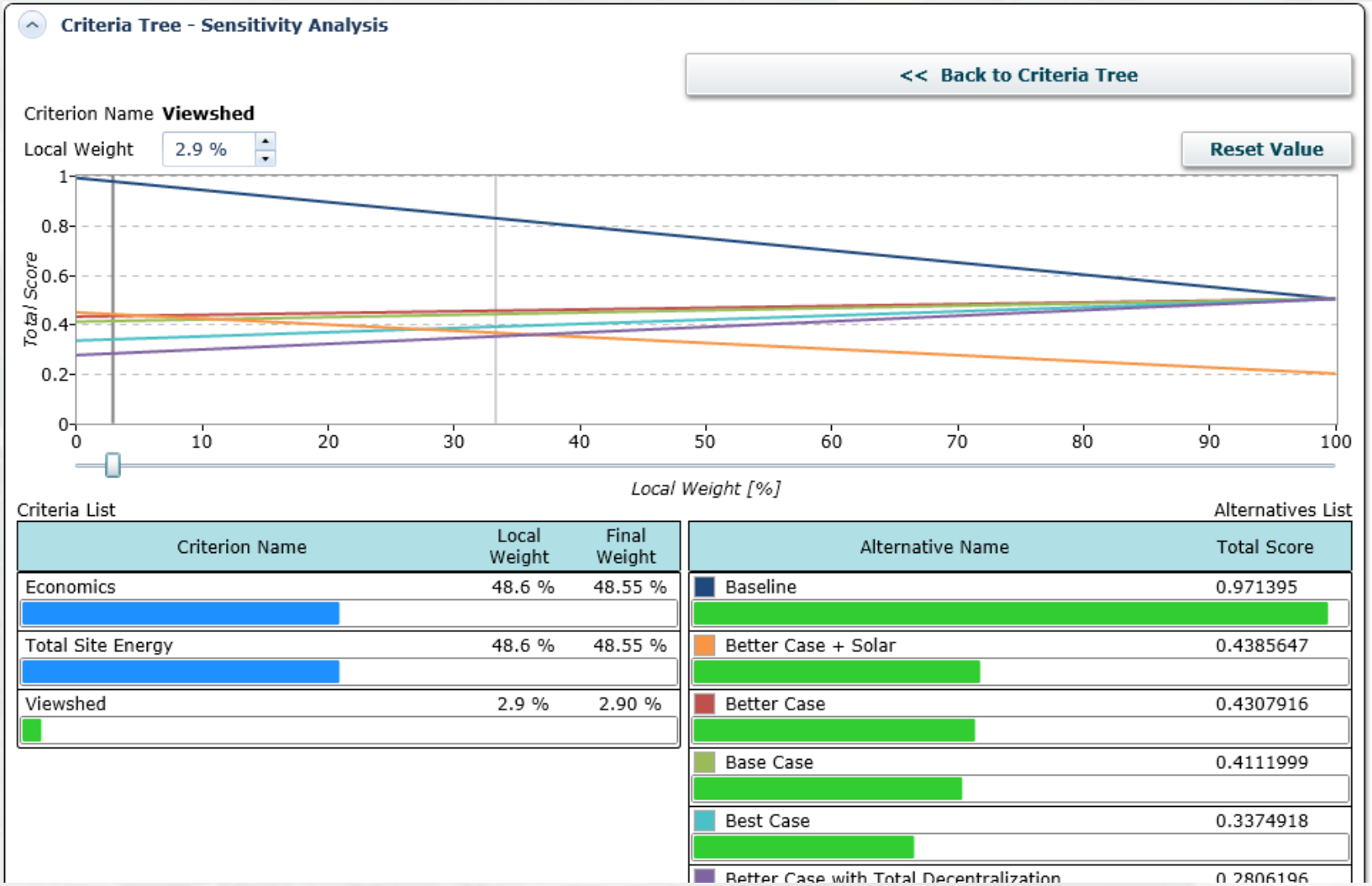


Create Value Function for the Community Sentiment Metric

- 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



Sensitivity Analysis
Low weight on view shed

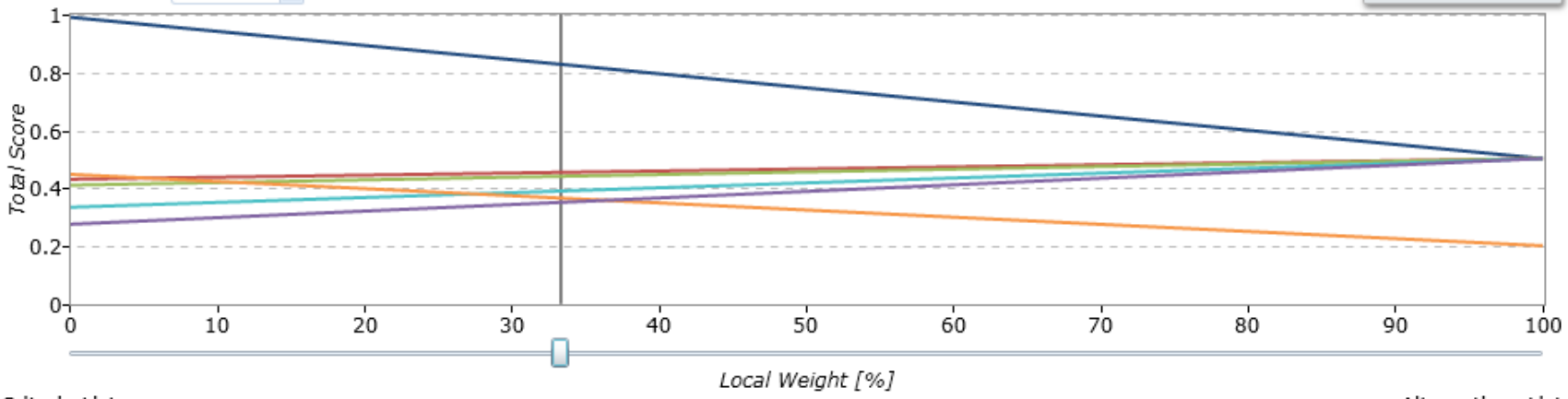


Sensitivity Analysis
Higher weight on view shed

Criterion Name **Viewshed**

Local Weight 33.3 %

Reset Value



Criteria List

Criterion Name	Local Weight	Final Weight
Economics	33.4 %	33.35 %
Total Site Energy	33.4 %	33.35 %
Viewshed	33.3 %	33.30 %

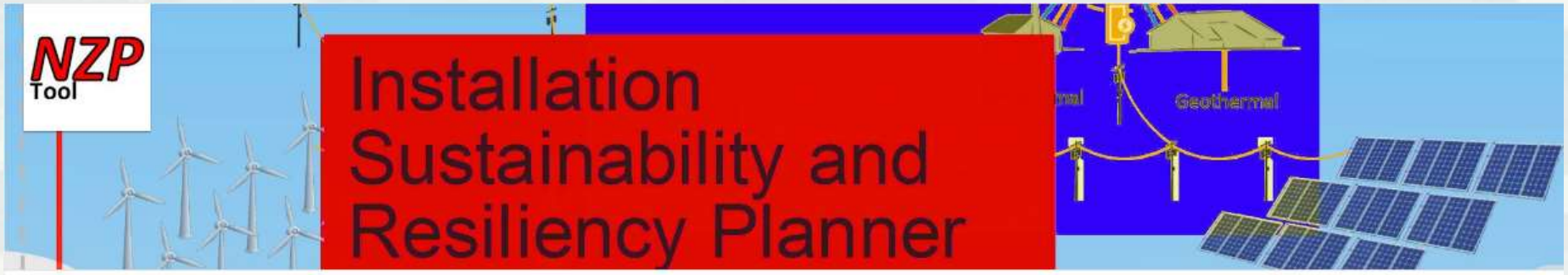
Alternatives List

Alternative Name	Total Score
Baseline	0.823811
Better Case	0.4524593
Base Case	0.4390014
Best Case	0.3883697
Better Case + Solar	0.363875
Better Case with Total Decentralization	0.349303

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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