Master Planning for Resiliency and Sustainability through Net Zero Modeling – NZP Tool ™

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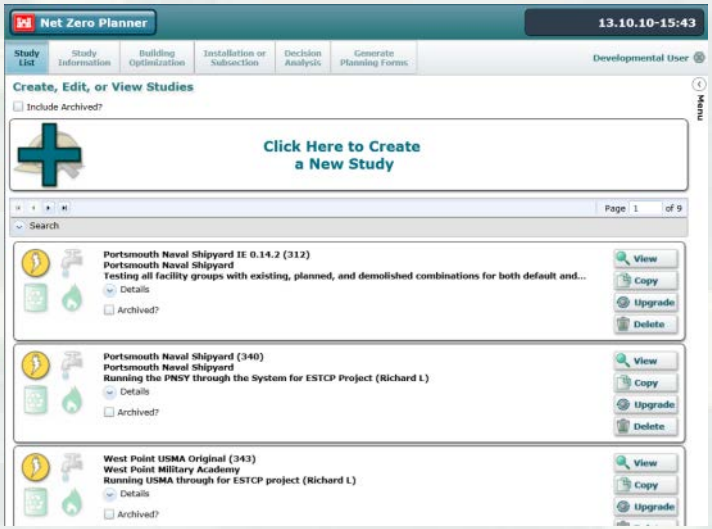
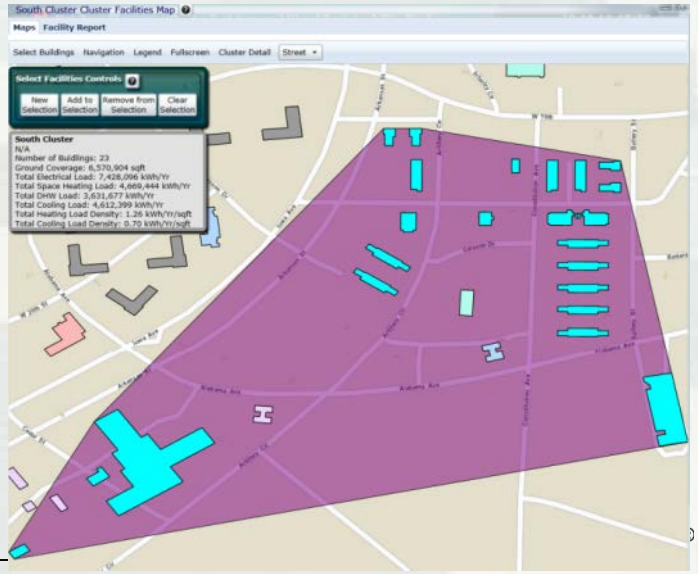
Definitions

- Framing Goal – A target goal for analysis. Not a commitment or decision.
- Baseline – A snapshot of the current energy use situation. The baseline is one reference point used to evaluate alternative futures.
- Future Base Case – The baseline extended to include 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 set of energy measures to be compared against the base case
  - Better, Best, Others
- Site Energy – Energy measured at the point of use.
- Source Energy – Energy measured at the point it is generated (takes into account conversion and transmission losses).
- District/Cluster - a group of buildings to be served by a microgrid/ heating/ cooling loop (or some combination of these)

The NZP Tool: Installation Sustainability and Resiliency Planner

- Web based tool that assists in energy, water, and waste (EW2) planning
- Easy to use after setup
- Projects EW2 usage, flows
- Provides ROI analysis for EW2 conservation measures
- Integrates with Master Planning Process
- Identifies a roadmap and projects
- Integrated Solid Waste and Water
- Integrated into Corps of Engineers sustainability planning process





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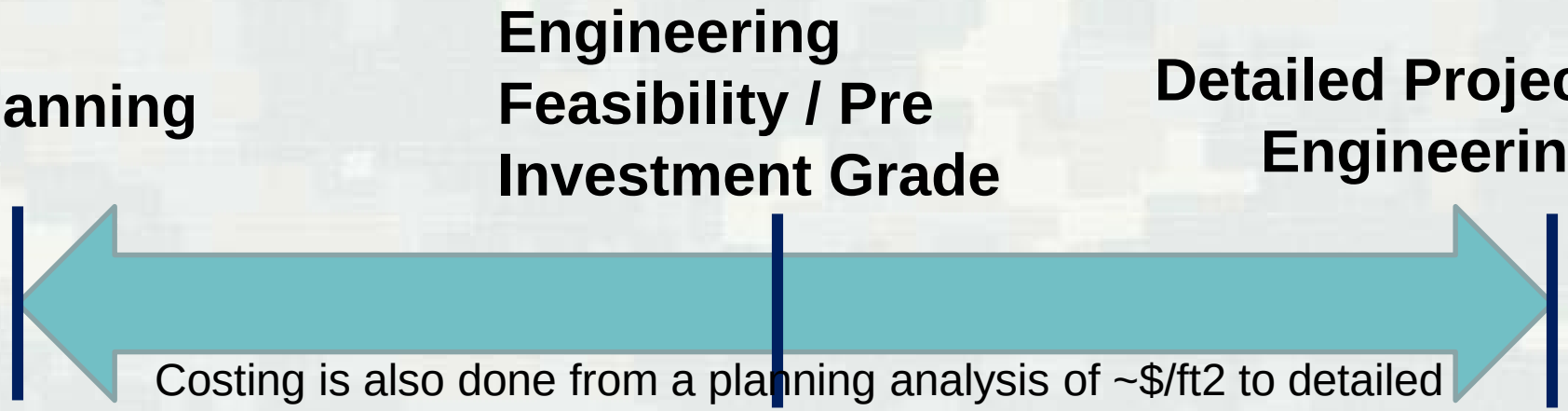
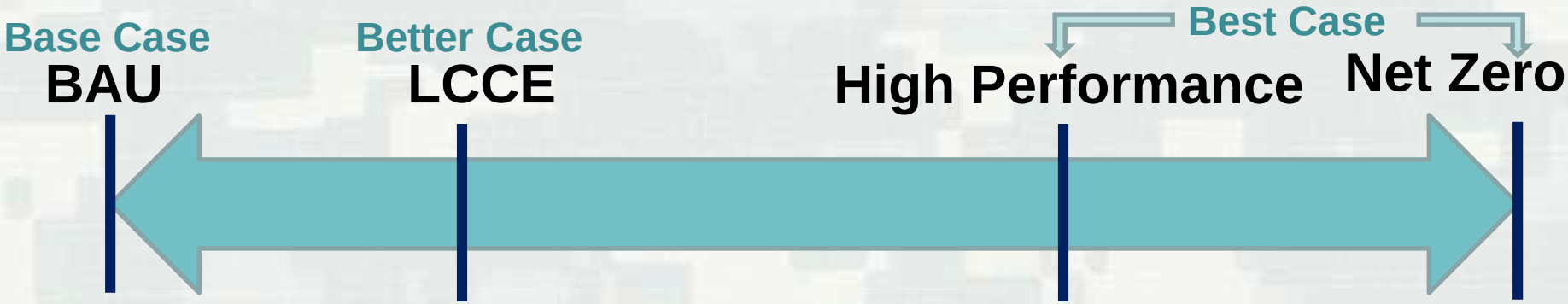
Continuum of Analysis Costs and Goals



Costing is also done from a planning analysis of ~$/ft2 to detailed project analysis done by Corps costing branch.



Framing Goals can be setup to cover the range from Business As Usual all the way to Net Zero. They can be analyzed anywhere in between as desired.

OSD Installation Energy Plans Memo, 31 March 2016

- OSD memo requiring all services to report in one year each agencies' plan to implementing an energy plan tied to the master plan by 2018.

Schofield Barracks, HI

Schofield Barracks, HI

OSD Installation Energy Plans Memo, 31 March 2016

- Phase 1: Identify the team, tasks, deliverables, and goals
- Phase 2: Establish baseline and future base case
- Phase 3: Analyze gaps and alternative scenarios
- Phase 4: Develop and sequence projects and activities
- Phase 5: Assemble review and finalize document
- Phase 6: Execution and maintenance of the IEP

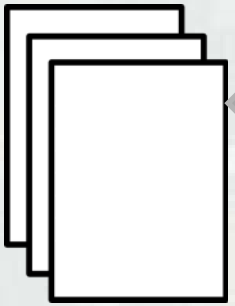
NZP Tool Process

Phase 6:
Maintenance of IEP

Execute, Track, Measure

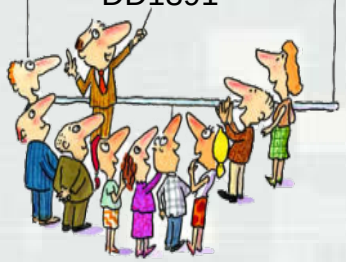
Phase 1:
Establish Planning Goals

Phase 2:
Establish Baseline and Future Base Case



Phases 4 & 5:
Produce & Finalize Integrated Plan Documents

- Integrated Plan
- Projects
- Sequence
- Schedule
- Costs
- Risk
- DD1391



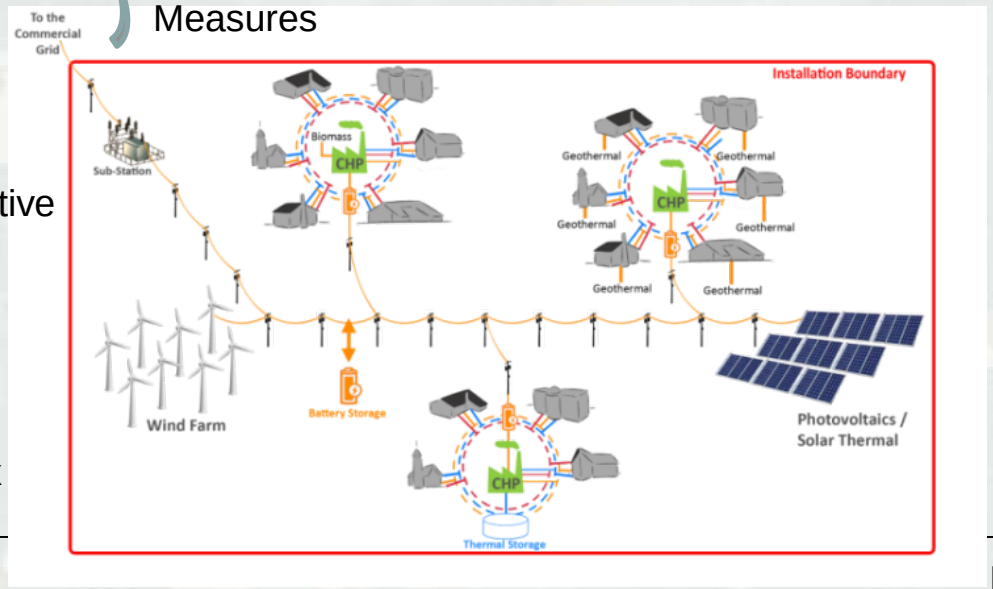
Supports

Optimize Building Energy Efficiency

Iterate over Building Measures

Phase 3:
Analyze alternative scenarios

Optimize Supply and Distribution System Mix



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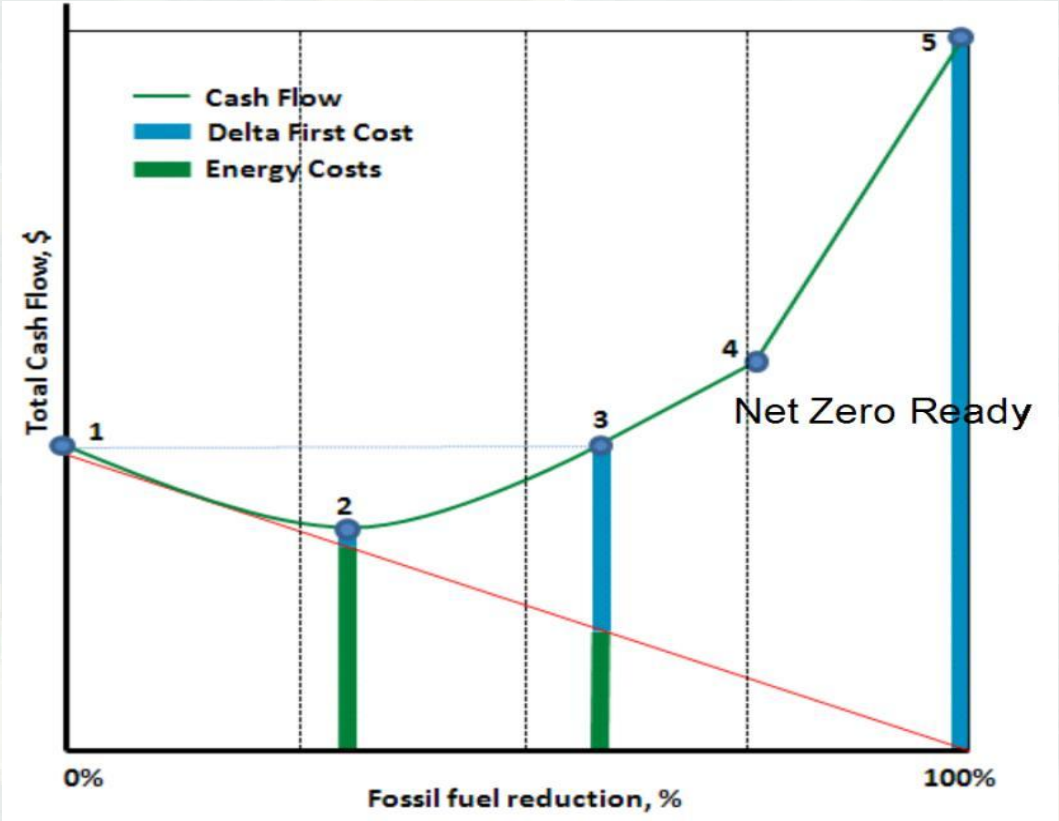
Energy and Sustainability Goals (example)

Parameter	2040 Base Case	2040 Target	Comments
Energy Efficiency %	Reference	40%	“Forty by Forty”
Source Energy Use	360,740 MWh	216,444 MWh	Based on Base Case
Site Energy Use	300,400 MWh	Derived	Depends on Scenario
GHG Reduction %	Reference	100%	Net Zero
Scope 1 & 2 Emissions	63,800 mt	Net Zero	
Energy Economics			Gov’t Analysis Life Cycle Cost Effective
Internal Rate of Return	NA	5%	Calculated over plan period
Energy Security	Acceptable	No Change	“Security and Efficiency”
Quality, reliability, resilience	NA	No change	Thermal and electric Equal or better than baseline

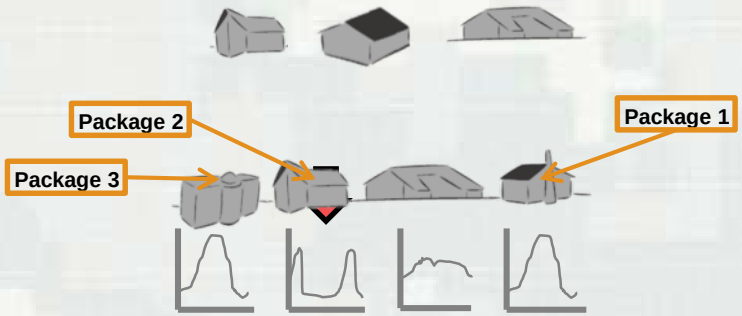
Cost-Optimizing Zero Energy Buildings

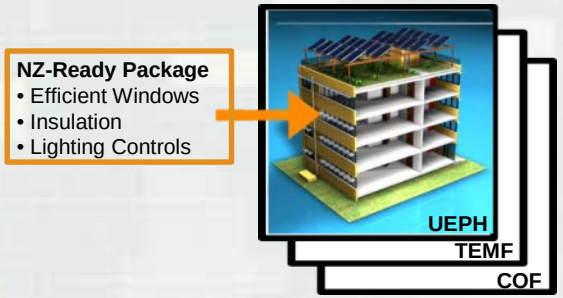
Integrating EEM's that are Net Zero Ready Cost Effective

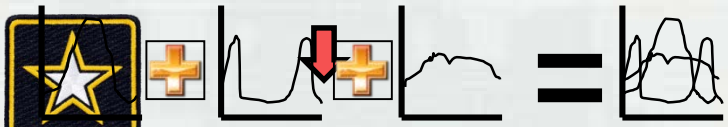
- 1. business as usual or the base case
- 2. least life cycle cost option
- 3. achieved the same total annual cost as your base case building, but the building at point 3 is more energy efficient and often more comfortable.
- 4. is the Crossover Point: where generating renewable energy is more cost-effective than additional Energy Efficiency Measures or **Net-Zero Ready. Point 4 is normally at 60% to 80% savings depending on building and location**



Building Simulation Process







1. Gather baseline information
2. Simulate baseline and EEM packages
3. Generate Cost/Energy curve and SIR for EEM packages
4. Select optimal EEM package for each building type
5. Initial building analysis complete. Prepare load profiles to pass to next phase for cluster analysis

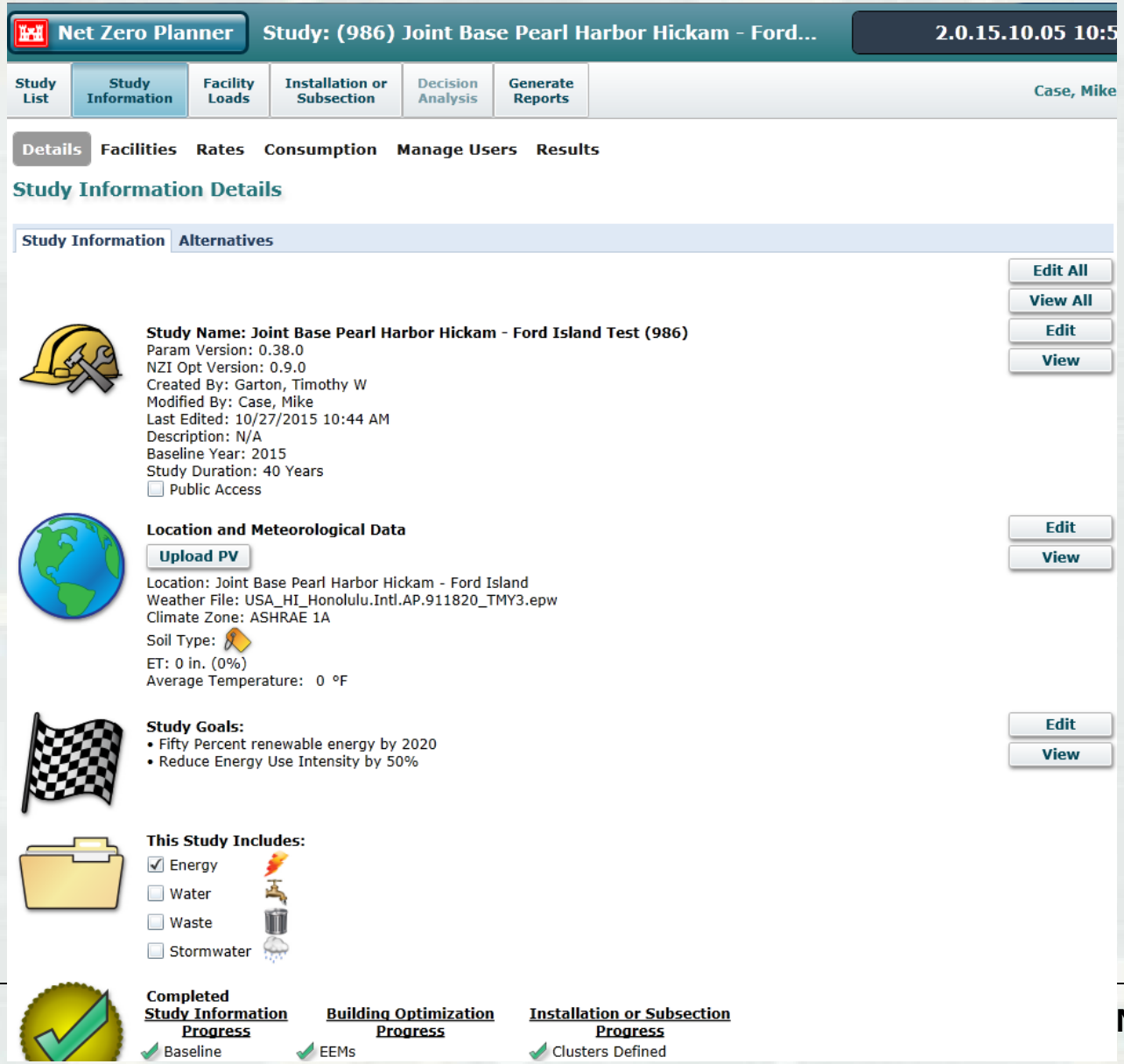
Description of Alternative Scenarios PNSY (Cold Weather example)

- **1. Baseline**:
  - Existing buildings and central plant equipment are simulated.
- **2. Basecase**:
  - buildings with planned construction, renovation, and demolition. Existing central plant equipment provides a “status quo” used as a comparison for the remaining scenarios.
- **3. District Steam**:
  - buildings with a modern steam system. One existing natural gas turbine is replaced with two natural gas reciprocating engines with approximately half the electrical output capacity each.
- **4. District hot water and spot steam (District Hot Water)**:
  - buildings with a modern hot water system and spot steam generation to meet process loads. Central plant same as District Steam scenario.
- **5. Decentralized**:
  - buildings with decentralized boilers/furnaces and spot steam generation to meet process load. The same level of electrical backup is still required (15.4 MW for the installation, as in the existing central plant).
- **6. Net-Zero Fossil Fuel (Net-Zero FF)**:
  - buildings with a modern hot water system and lowest equivalent annual cost equipment to meet net zero fossil fuel goals. Only analyzed using the NZP tool.

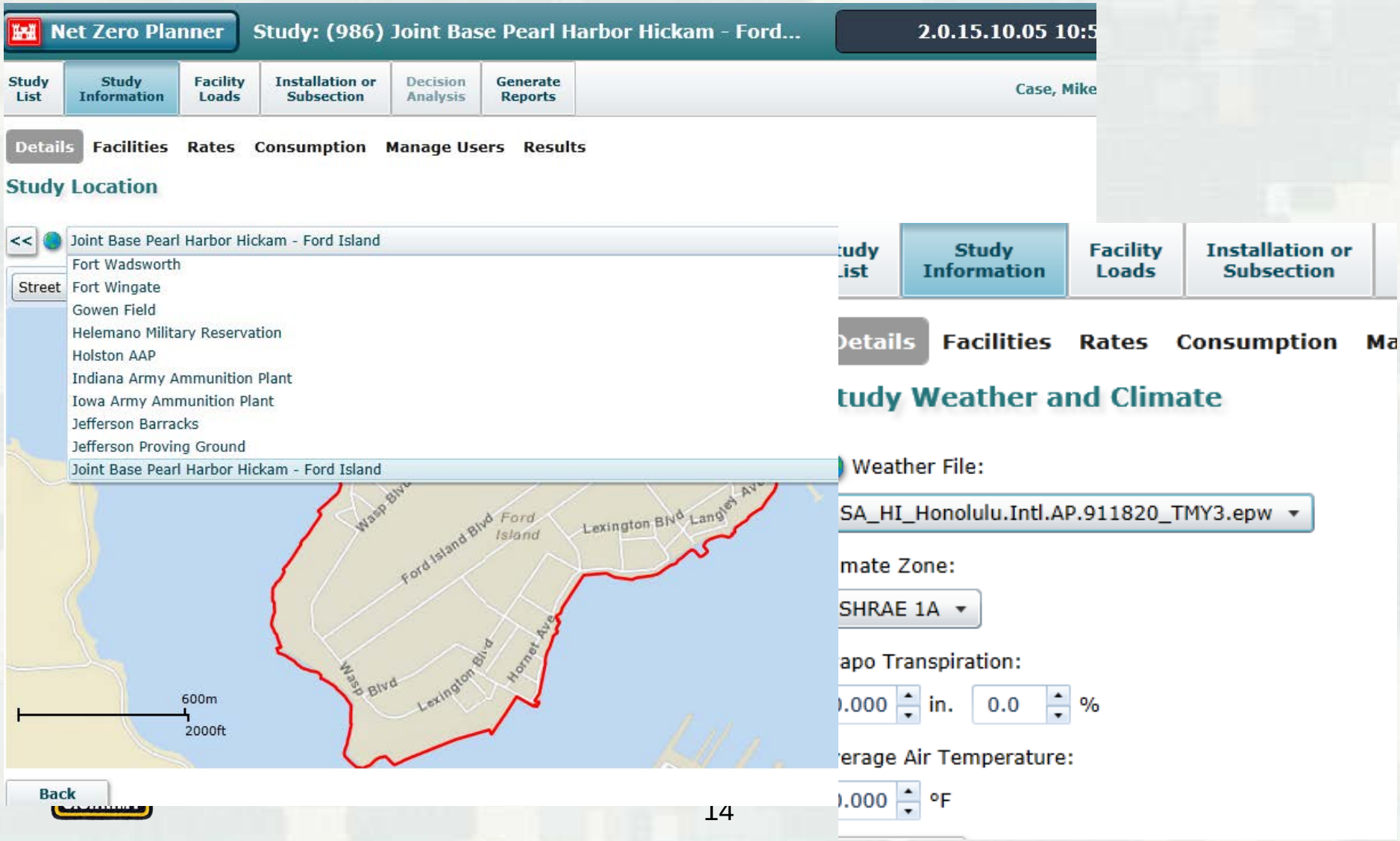
Description of Alternatives
JBPHH (Warm Weather Example)

- **1. Baseline**:
  - Existing buildings are simulated. No heating.
- **2. Basecase**:
  - buildings with planned construction, renovation, and demolition. No existing central plant or cooling systems
- **3. Better Case**:
  - Minor EEM improvements to buildings
- **4. Best Case:**
  - Aggressive EEM improvements to buildings.
- **5. Best Case w/ 50% renewables**:
  - Meet half of best case electrical loads with non-fossil fuel source
- **6. Best Case net zero**
  - buildings with a modern hot water system and lowest equivalent annual cost equipment to meet net zero fossil fuel goals. Only analyzed using the NZP tool.

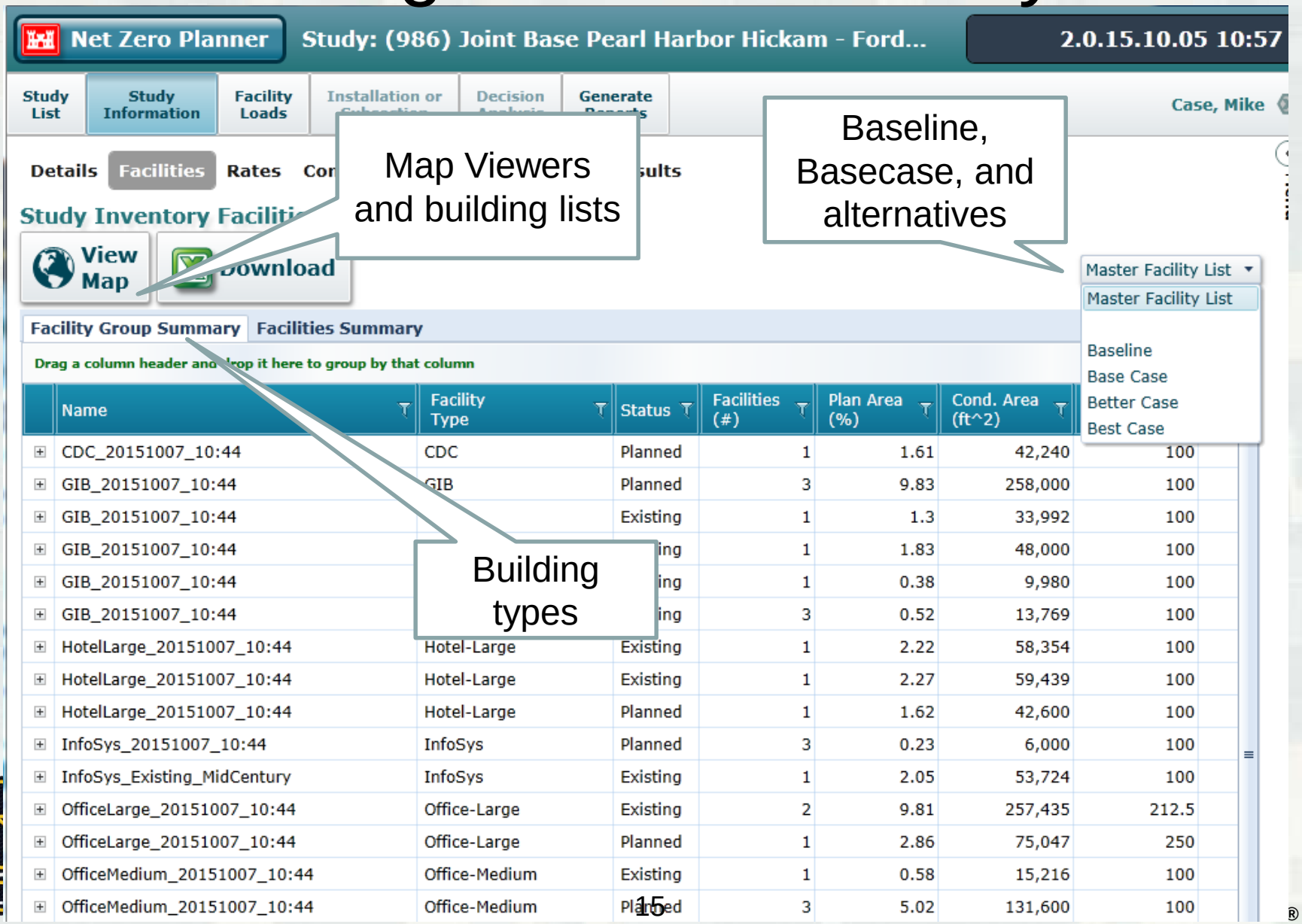
Study Setup and Information



Many DoD Installations in system, with weather

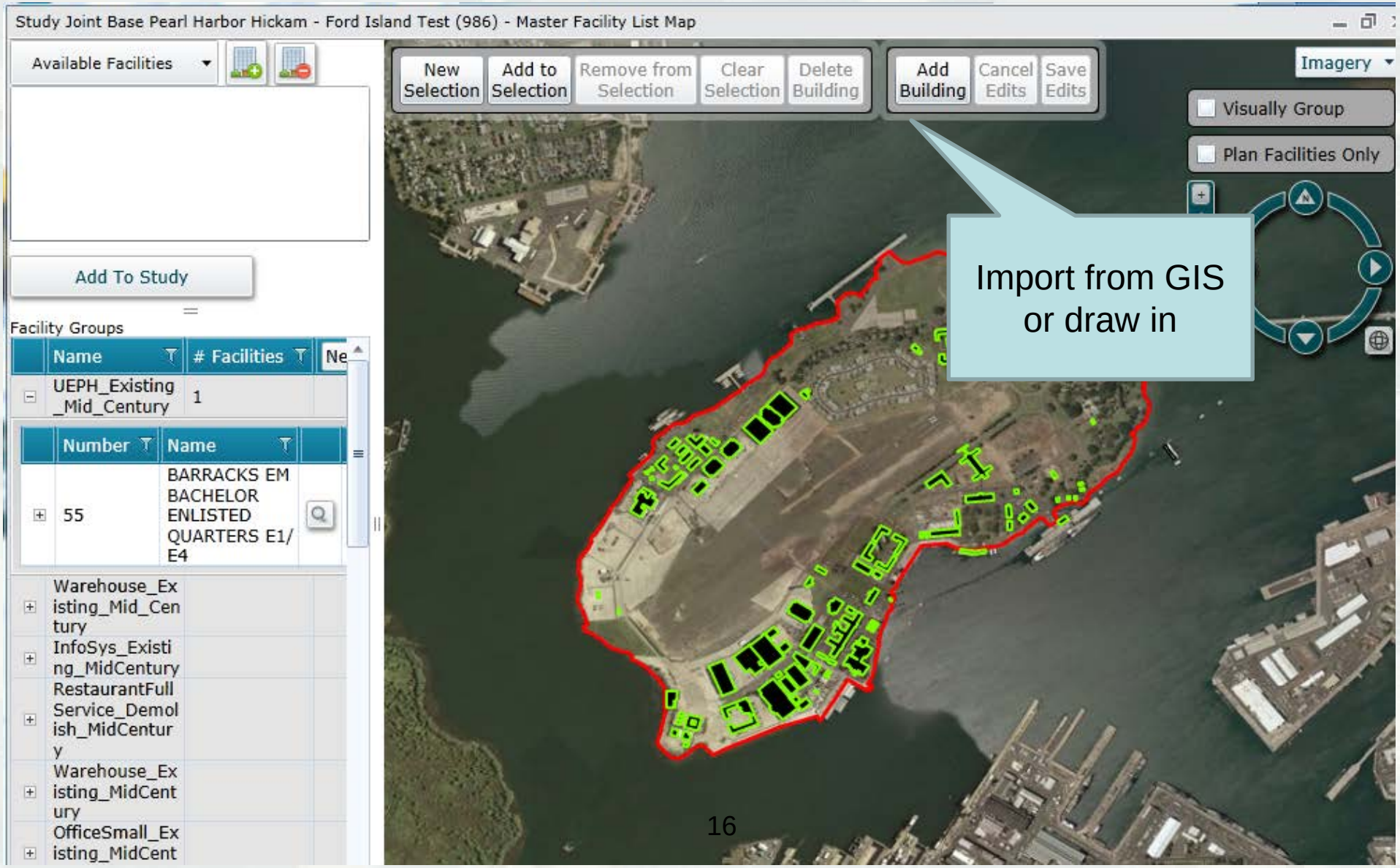


Adding Facilities is Easy

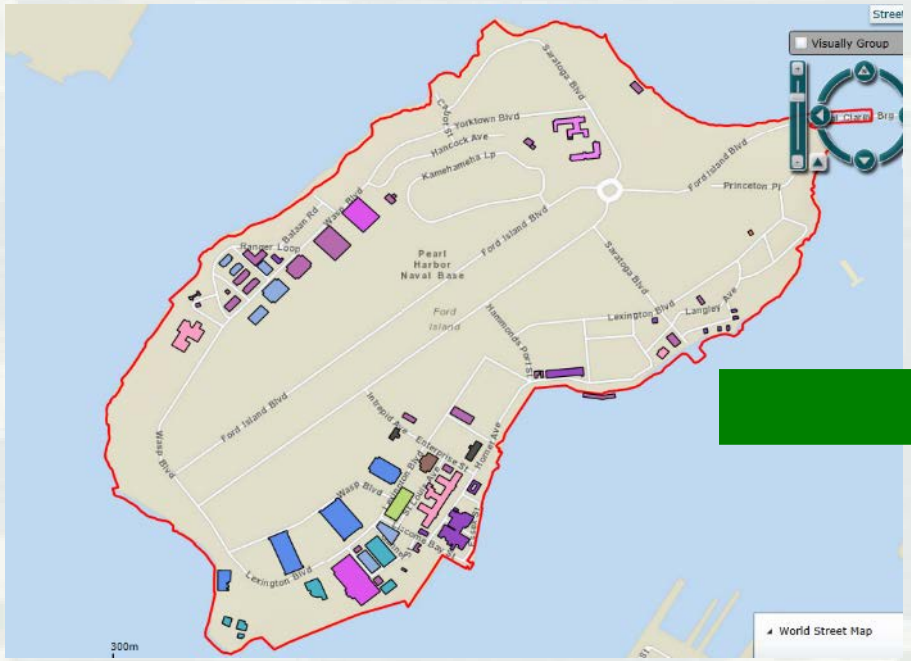


Name	Facility Type	Status	Facilities (#)	Plan Area (%)	Cond. Area (ft^2)	
CDC_20151007_10:44	CDC	Planned	1	1.61	42,240	100
GIB_20151007_10:44	GIB	Planned	3	9.83	258,000	100
GIB_20151007_10:44		Existing	1	1.3	33,992	100
GIB_20151007_10:44		ing	1	1.83	48,000	100
GIB_20151007_10:44		ing	1	0.38	9,980	100
GIB_20151007_10:44		ing	3	0.52	13,769	100
HotelLarge_20151007_10:44	Hotel-Large	Existing	1	2.22	58,354	100
HotelLarge_20151007_10:44	Hotel-Large	Existing	1	2.27	59,439	100
HotelLarge_20151007_10:44	Hotel-Large	Planned	1	1.62	42,600	100
InfoSys_20151007_10:44	InfoSys	Planned	3	0.23	6,000	100
InfoSys_Existing_MidCentury	InfoSys	Existing	1	2.05	53,724	100
OfficeLarge_20151007_10:44	Office-Large	Existing	2	9.81	257,435	212.5
OfficeLarge_20151007_10:44	Office-Large	Planned	1	2.86	75,047	250
OfficeMedium_20151007_10:44	Office-Medium	Existing	1	0.58	15,216	100
OfficeMedium_20151007_10:44	Office-Medium	Planned	3	5.02	131,600	100

Uses Available GIS information



Compare “as-is” to future scenarios



Present Day

Planned

Energy Efficiency Measures (EEM)

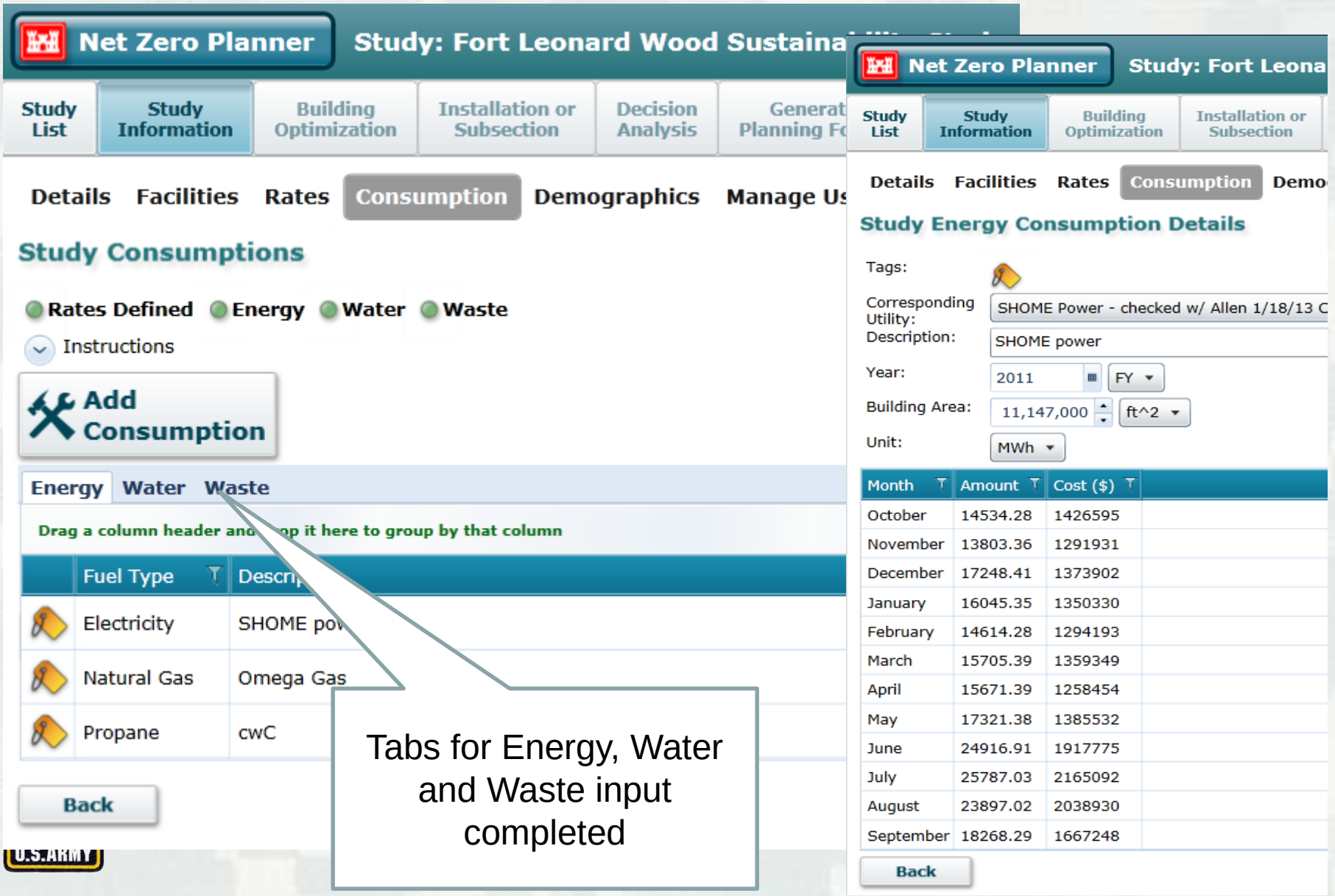
- Often called Energy Conservation Measures (ECM)
- Applied to a facility to decrease energy use
- Can be applied as *Packages* or *Bundles*
  - ► Cherry-picking
  - ► Energy Service Company (ESCOs)
- Must be analyzed as a system
- Implementation costs
  - ► Many measures not cost effective on their own
  - ► Deep retrofit
- Opportunity for benchmarking

Energy Strategies

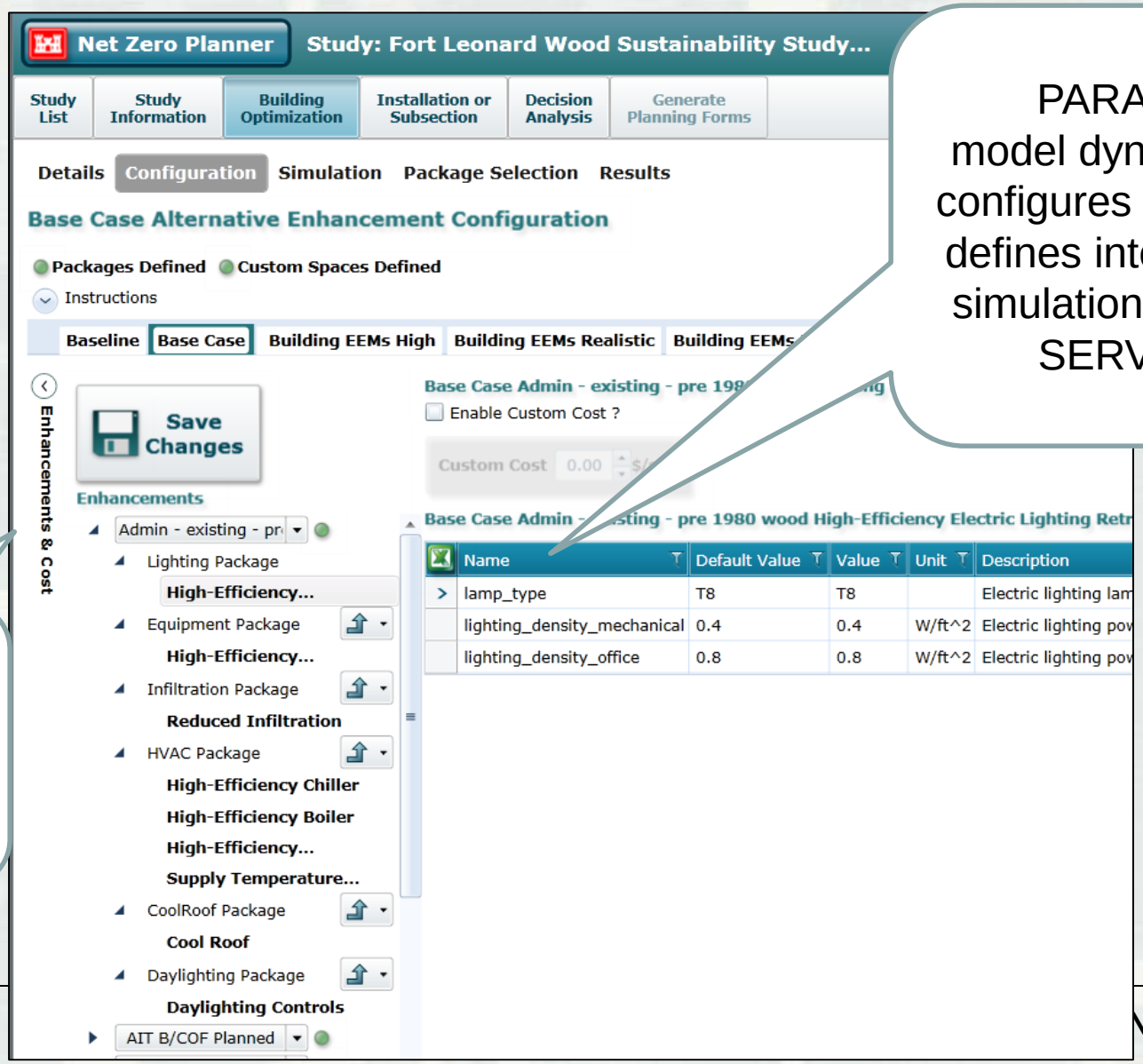
- Reduction (EEMs)
  - Insulation & Infiltration
  - Lighting & Daylighting
  - Lighting
  - High-Efficiency Equip
  - High-Efficiency HVAC
  - Energy Recovery
  - Dedicated Outside Air Systems
  - Cool Roofs
  - Metering
  - Building Automation

- Supply & distribution
  - Renewable energy - PV
  - Cogeneration/CHP
  - Large and Small-Scale District Energy
  - Thermal Storage
  - Biomass
  - Wind

Rates and Consumption



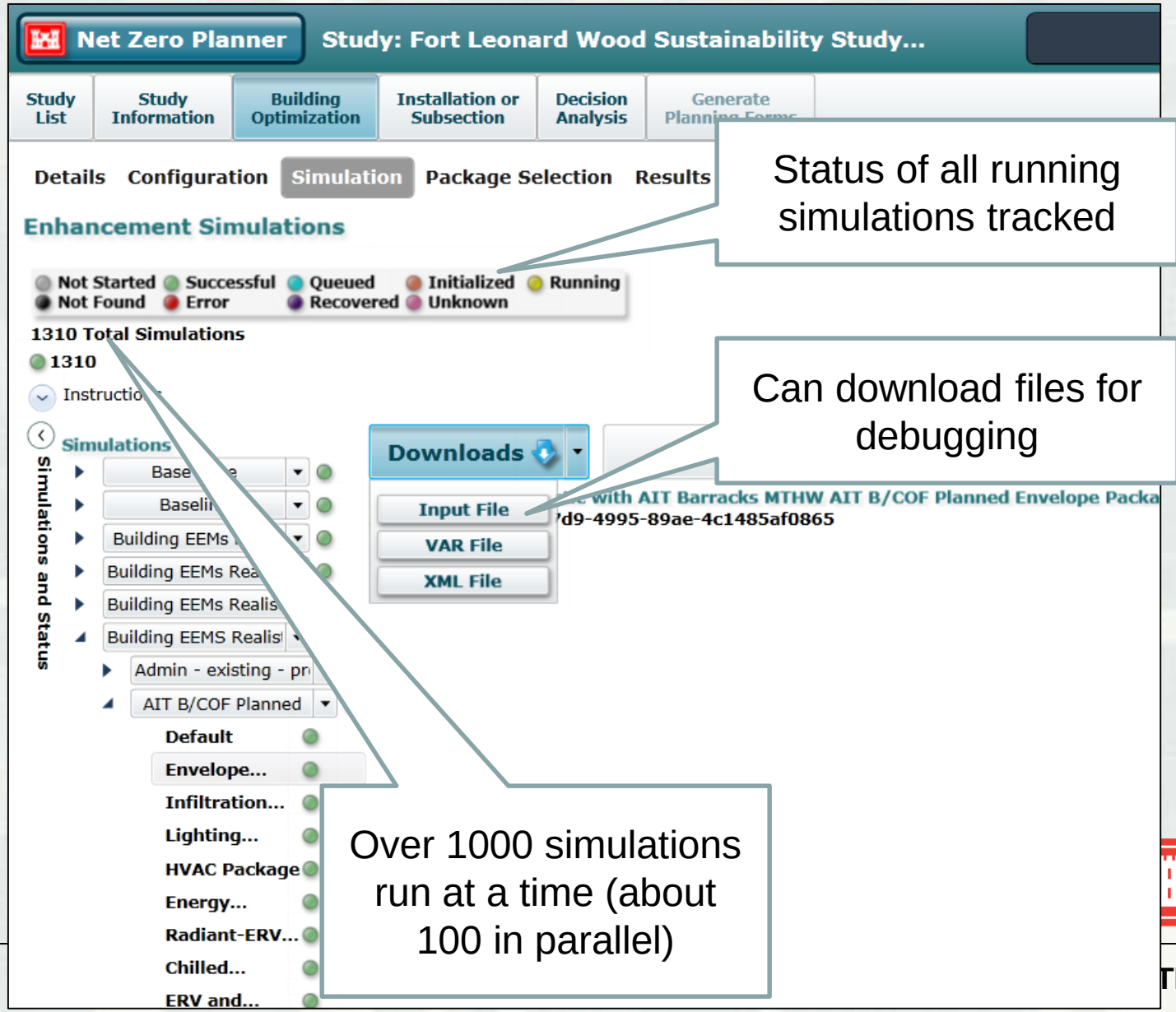
Configuration of measures



PARAMS model dynamically configures GUI and defines interface to simulation on JOB SERVER

Energy Efficiency Measures

Simulations on server farm



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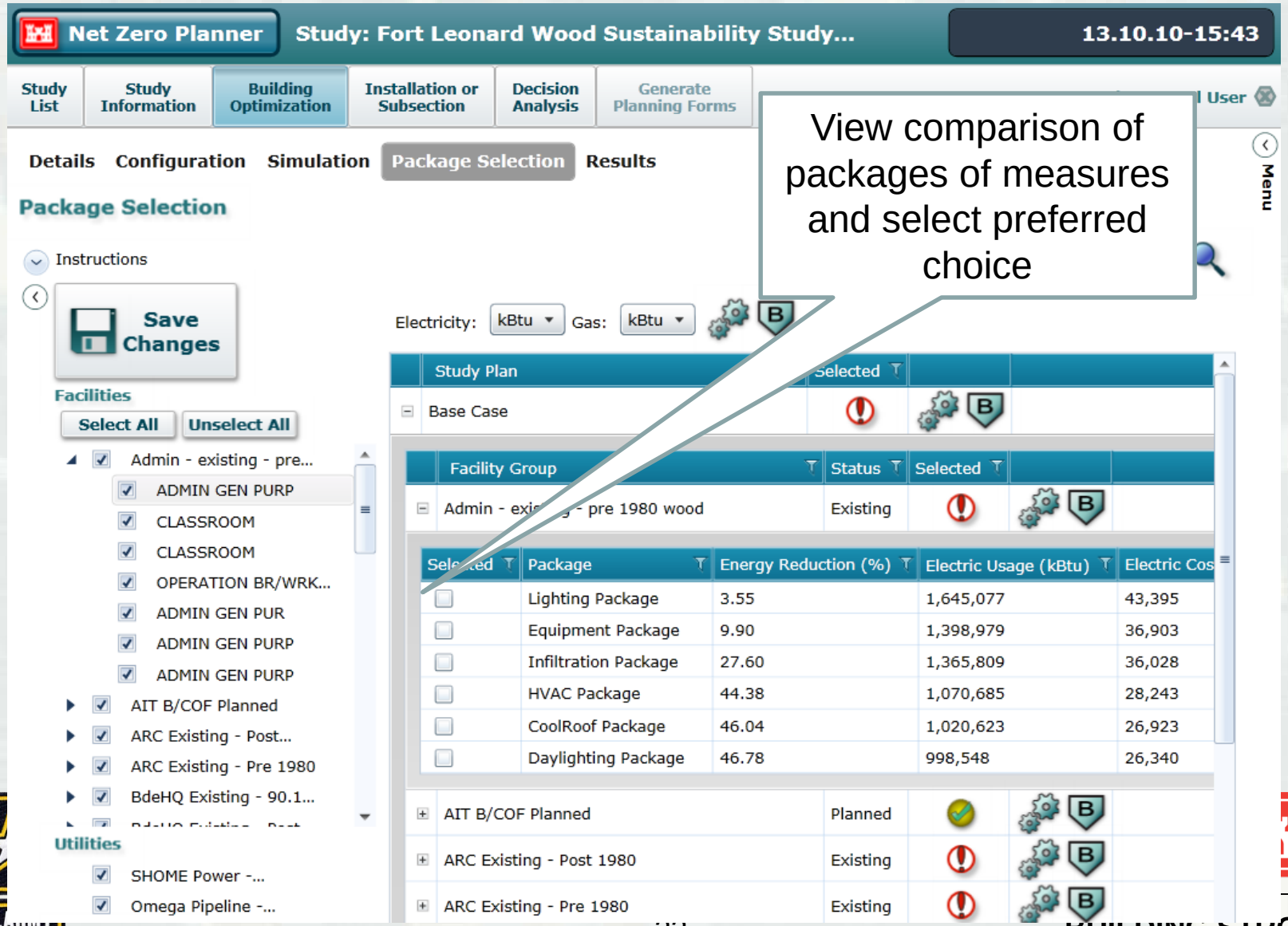
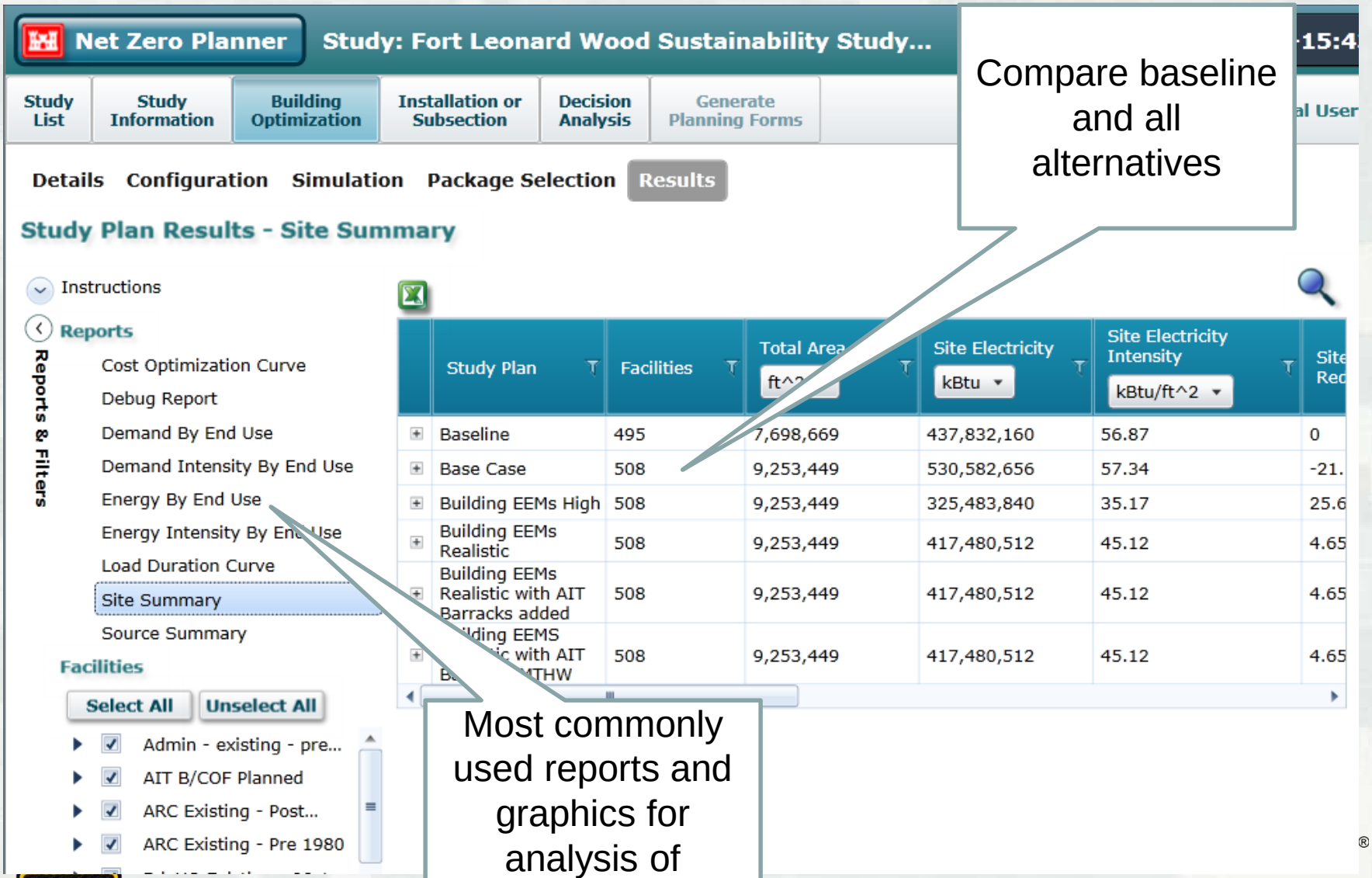
Package Selection



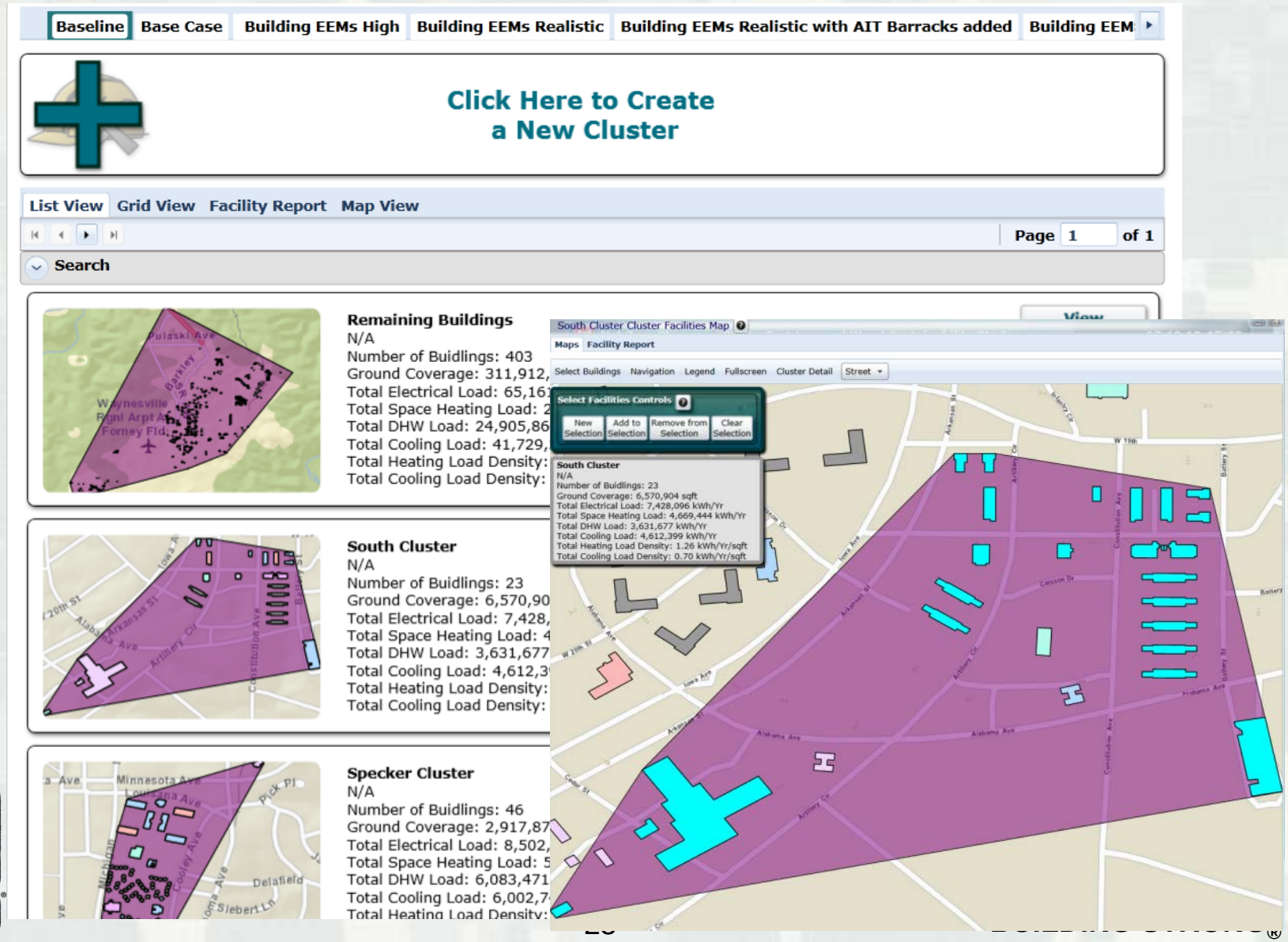
Building Level Reports



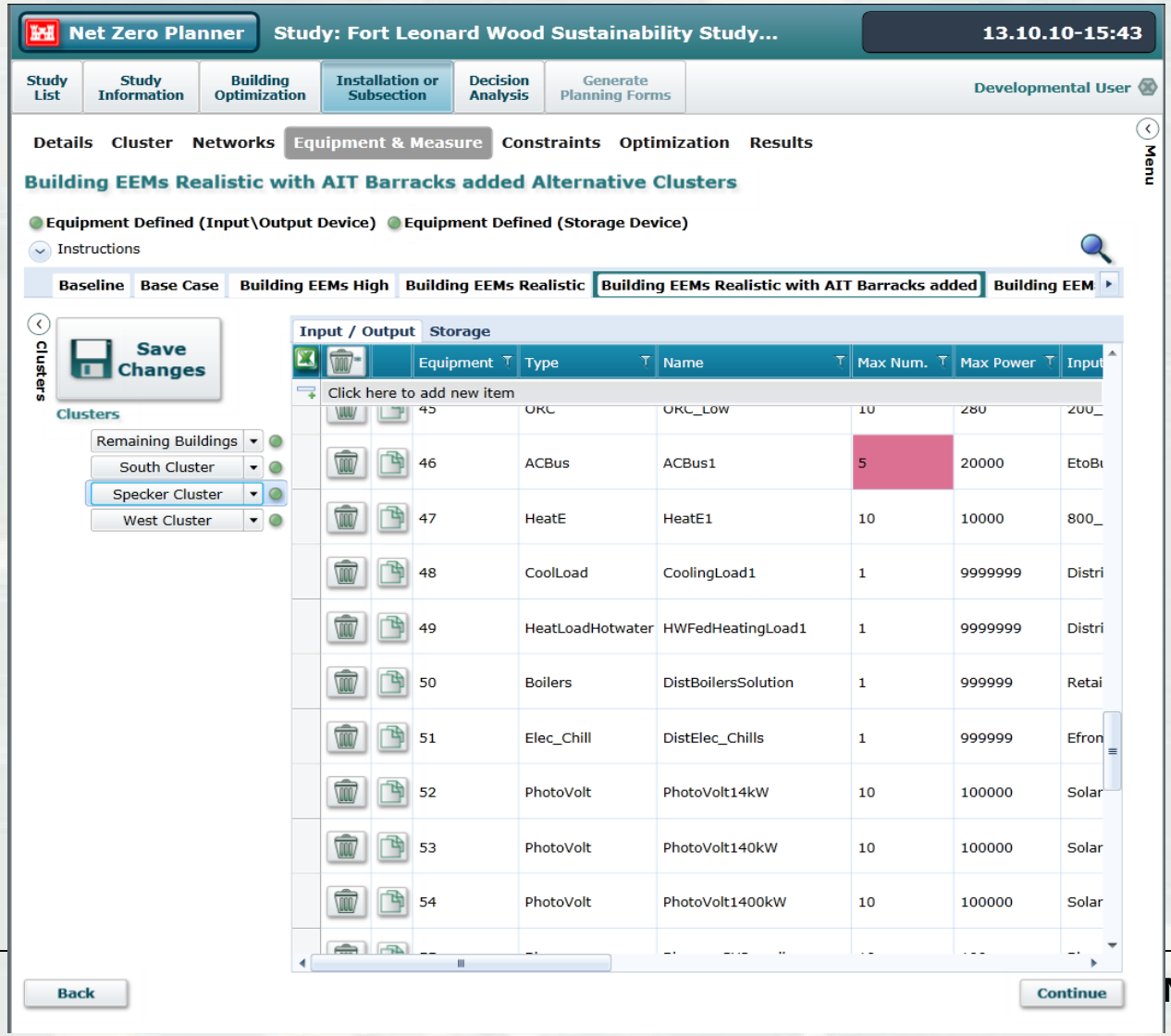
Compare baseline and all alternatives

Most commonly used reports and graphics for analysis of buildings

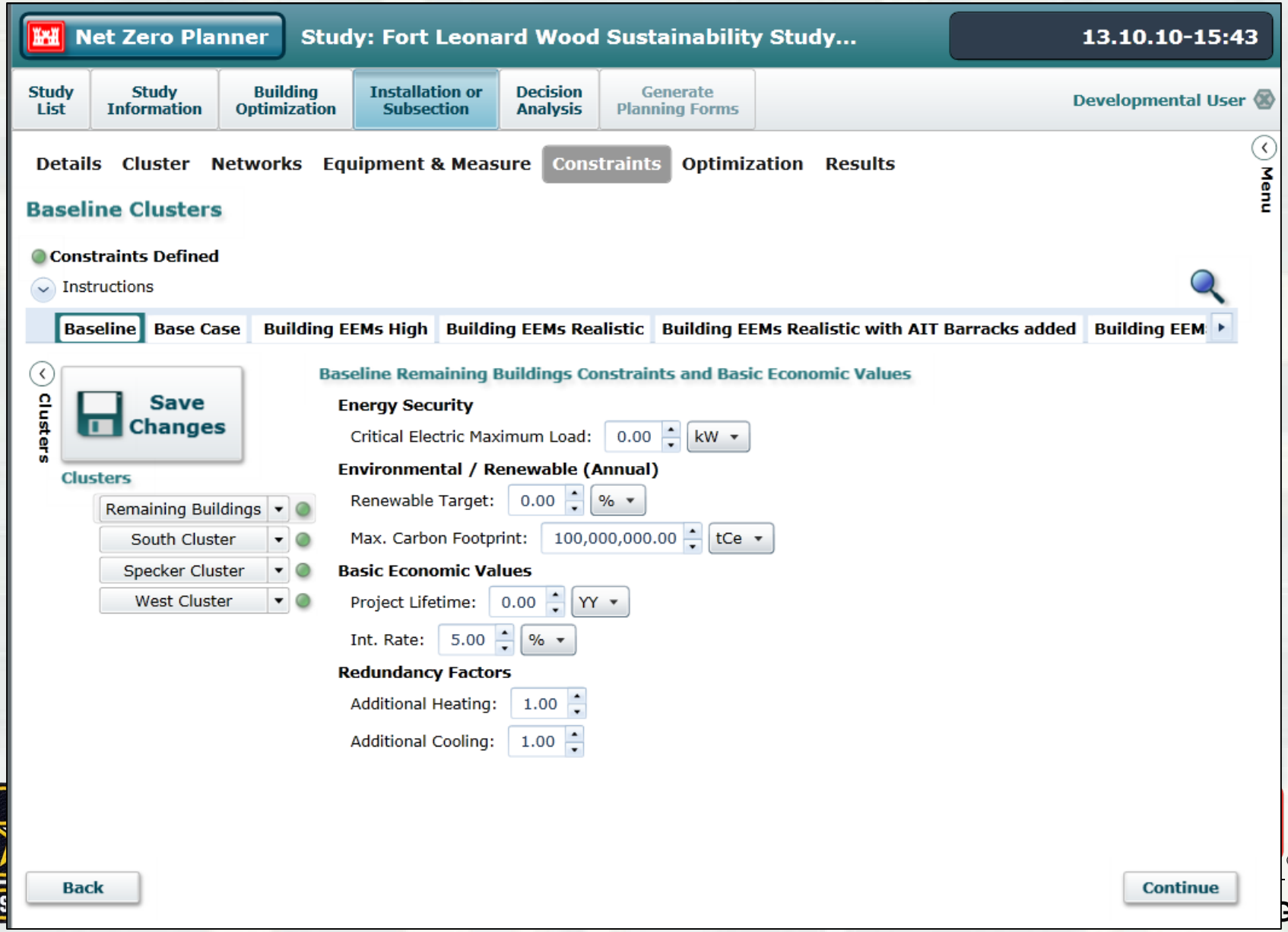
Installation-wide Analysis: Clusters



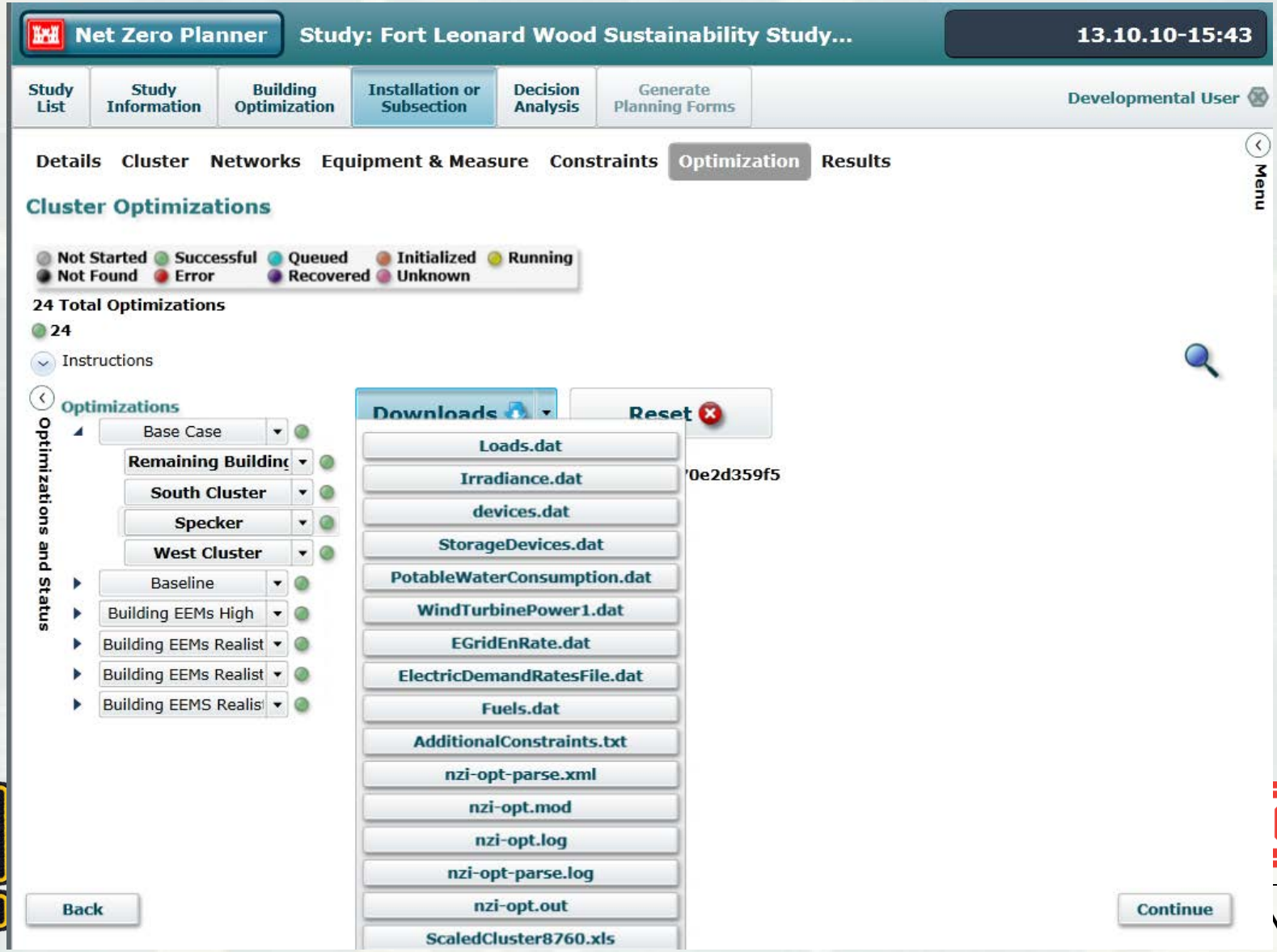
Choosing Equipment to Include in Optimization



Set Constraints for Optimization



Cluster Optimization



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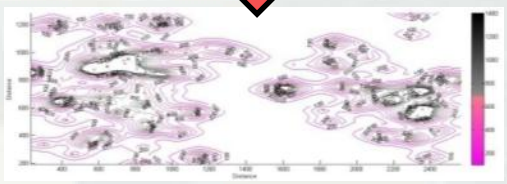
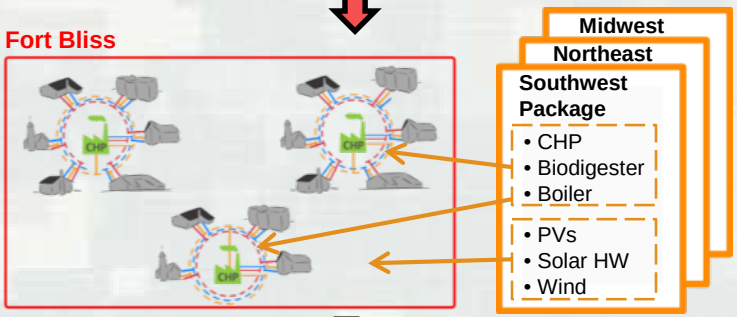
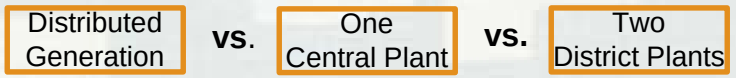
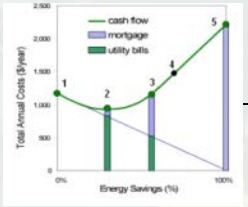
Installation Optimization Process





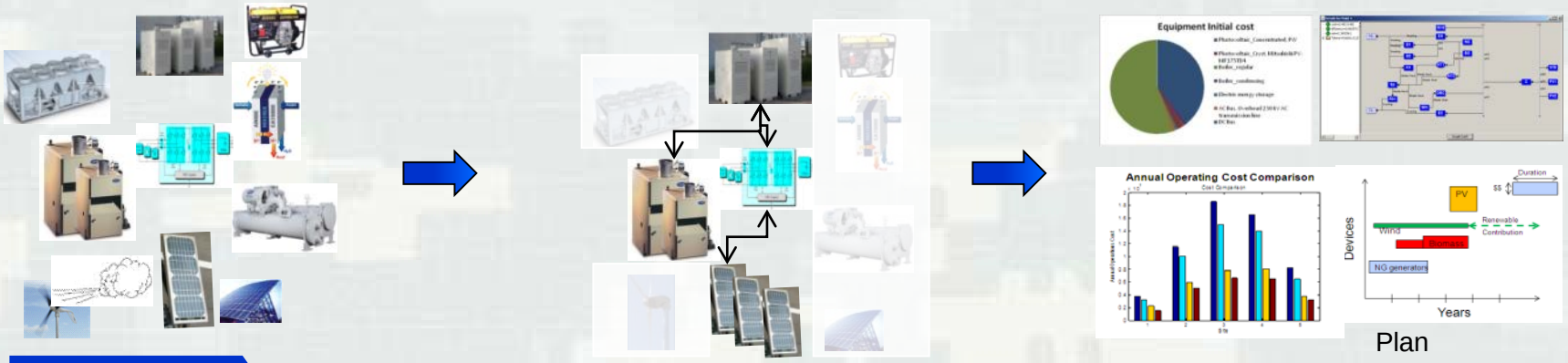




1. Integrate all building energy demands
2. Use energy density to identify possible clusters
3. Determine potential cluster equipment packages for installations and region
4. Generate alternative equipment configurations, including centralized and decentralized options
5. Optimize equipment size and pipe sizes
   - Electric, thermal, hydraulic, economic simulations
6. Calculate $SIR_{cluster}$ & EEMs

NZI Optimization Tool (NZI-Opt)

NZI-Opt is an optimization tool that is used to find the lowest life cycle-cost equipment suite to meet the “cluster level” demands while meeting a set of defined constraints. Cluster level demands can include heating, cooling, electric, critical electric, water, waste, etc.



Exploration Space (“Super-Structure”)

Architecture(s) determined

Reporting & Implementation Plan

How it works

NZI-Opt begins with definitions for all possible equipment pieces that could serve the cluster demands. These definitions include region-independent parameters such as efficiency, energy inputs, and energy outputs. Some equipment examples are shown below.

Electric Chiller

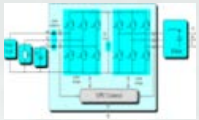
Photovoltaic

Absorption Chiller

Gas Boiler

Organic Rankine Cycle

Diesel Generator



AC Bus

Fuel Cell

Wind Turbine

Gas Turbine

Electric Heater

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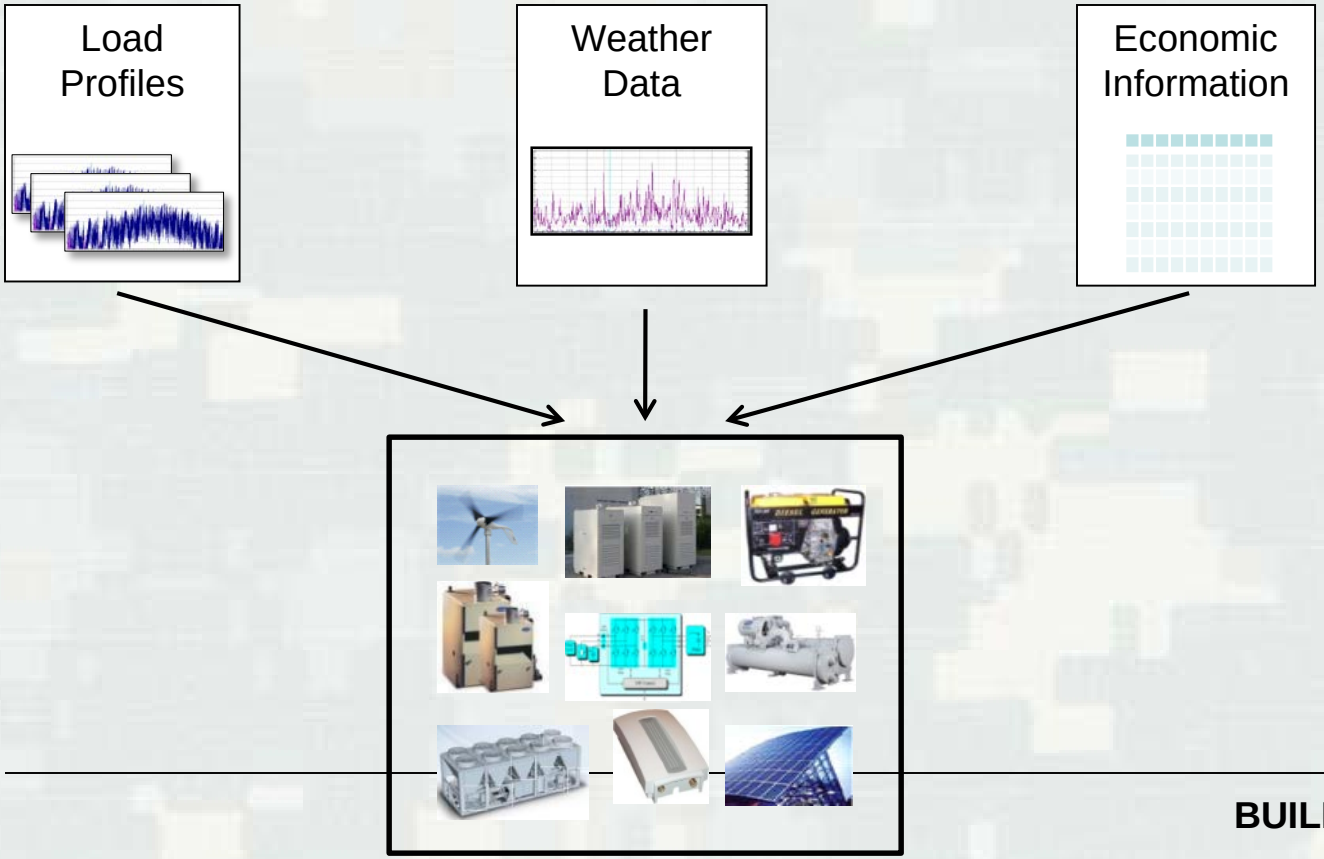
Installation Specific Inputs

Load profiles are input to provide the demands that must be met by the "supply" equipment. Weather data provides the necessary information for determining the potential of renewable sources. Economic data provides regionally specific information on utility cost schedules, equipment installation and maintenance costs, and fuel prices.



Selecting a Supply Architecture

The optimization process determines the best suite of equipment by ensuring that the demands for heat, cooling, electric, etc are fulfilled at each of the 8760 hours in the year, while satisfying the additional environmental and legislative requirements.

Electric Chiller

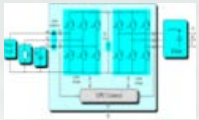
Photovoltaic

Absorption Chiller

Gas Boiler

Organic Rankine Cycle

Diesel Generator



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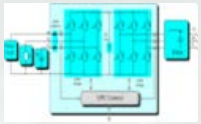

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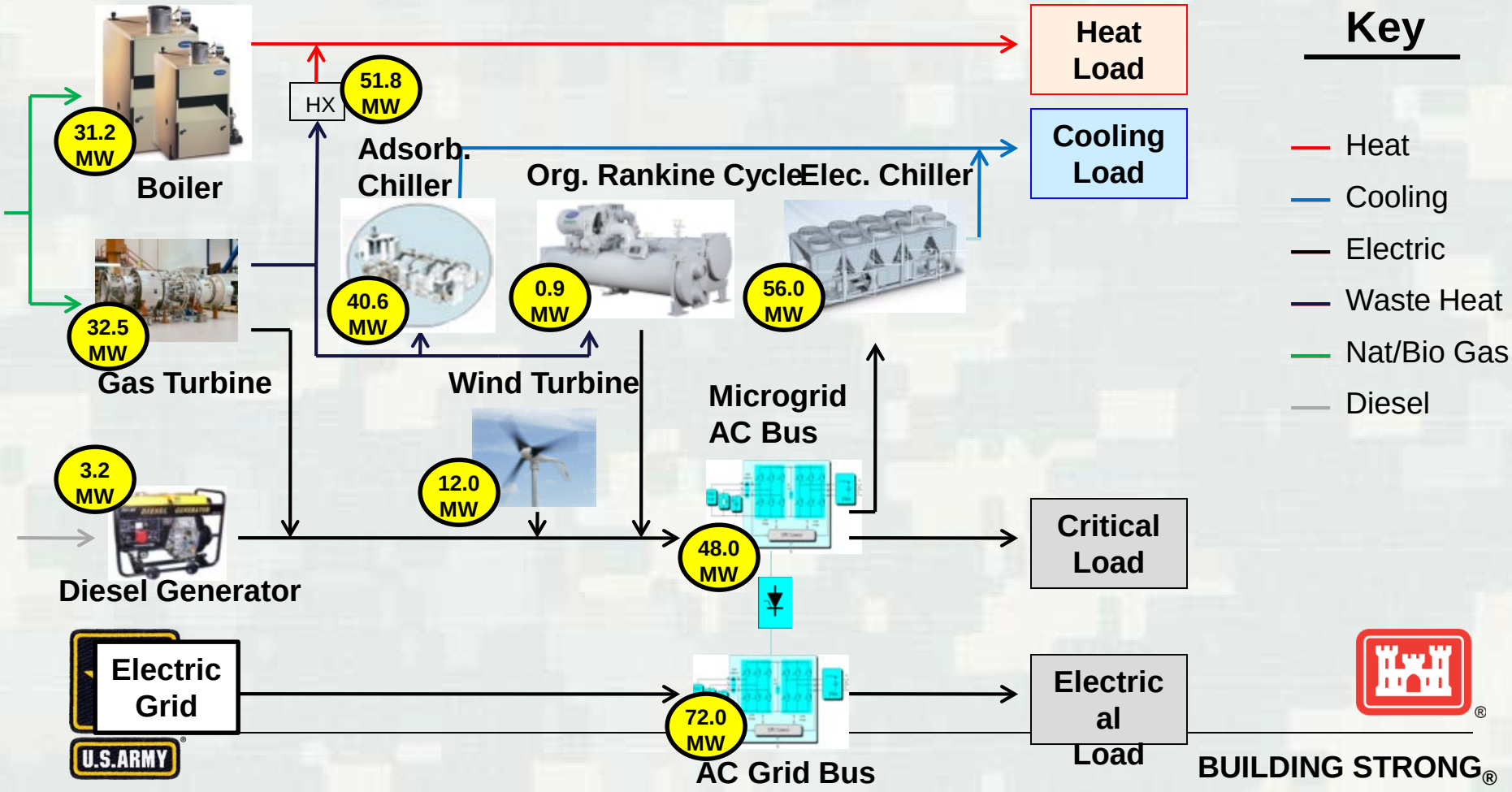
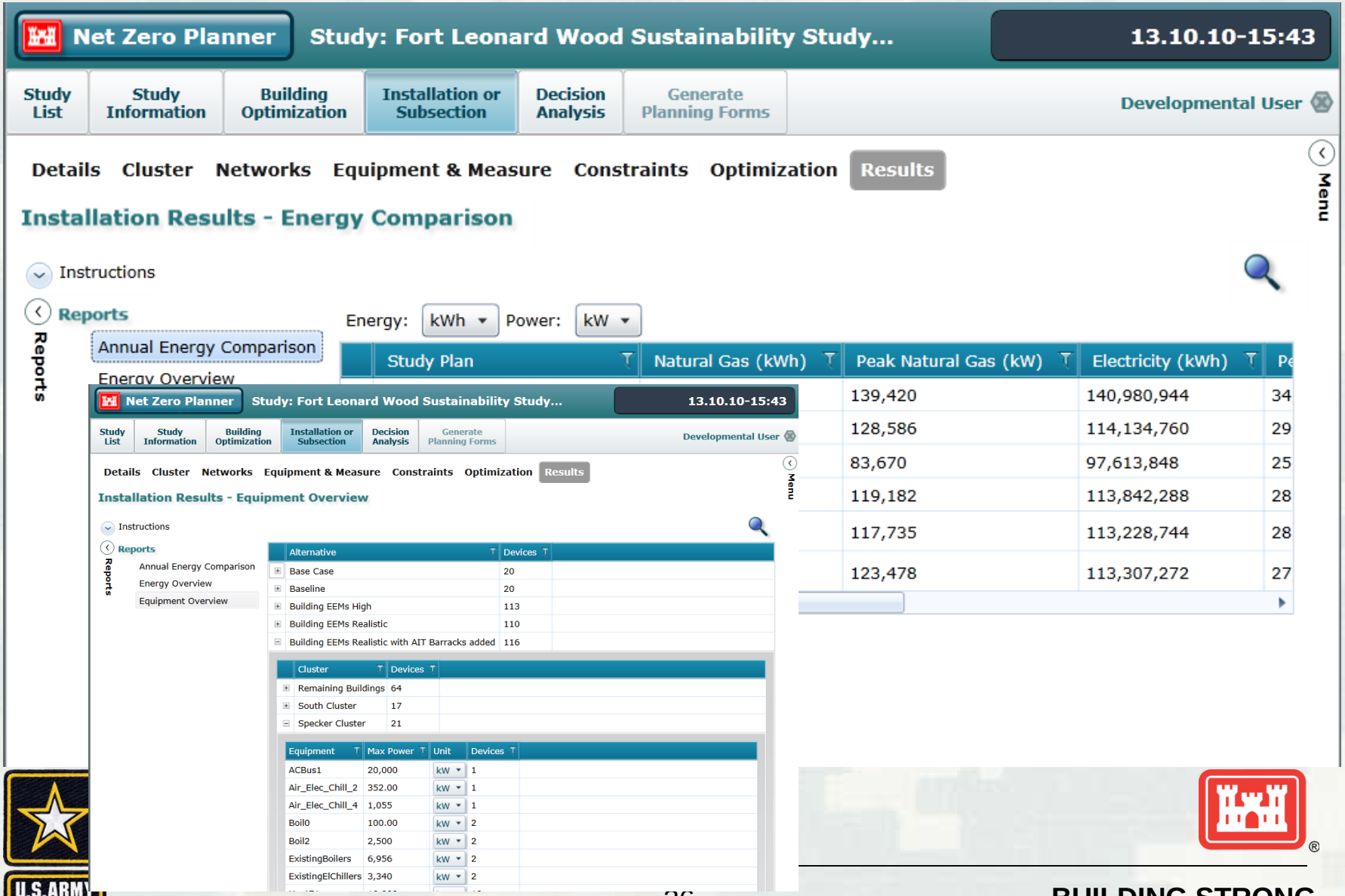
Sizing the Supply Equipment

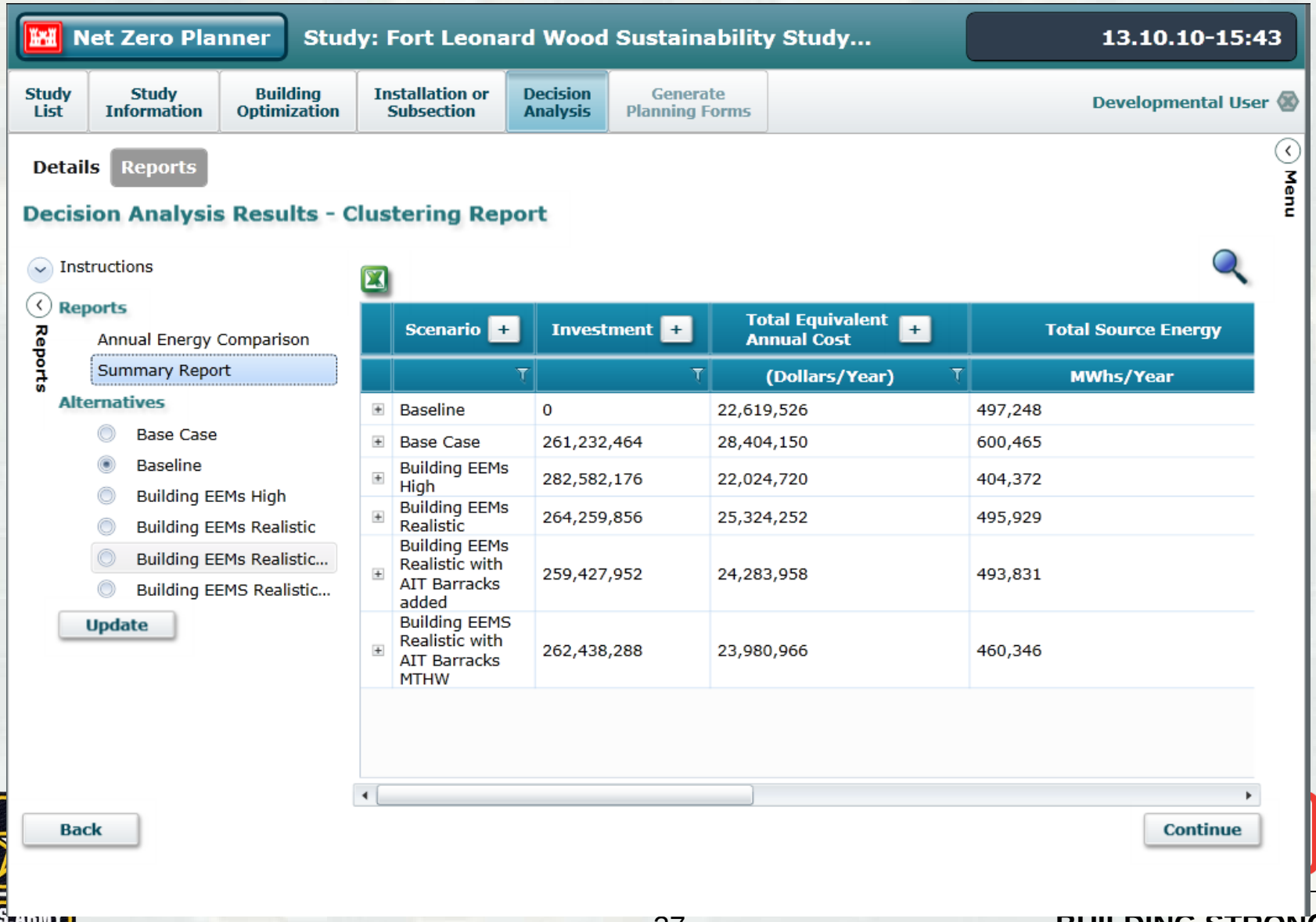
Specific equipment pieces are sized and their interactions with each other are tracked throughout the year. The result is a complete “supply” solution that provides the sizing, initial cost, and operating cost of every piece of equipment in the lowest cost solution.



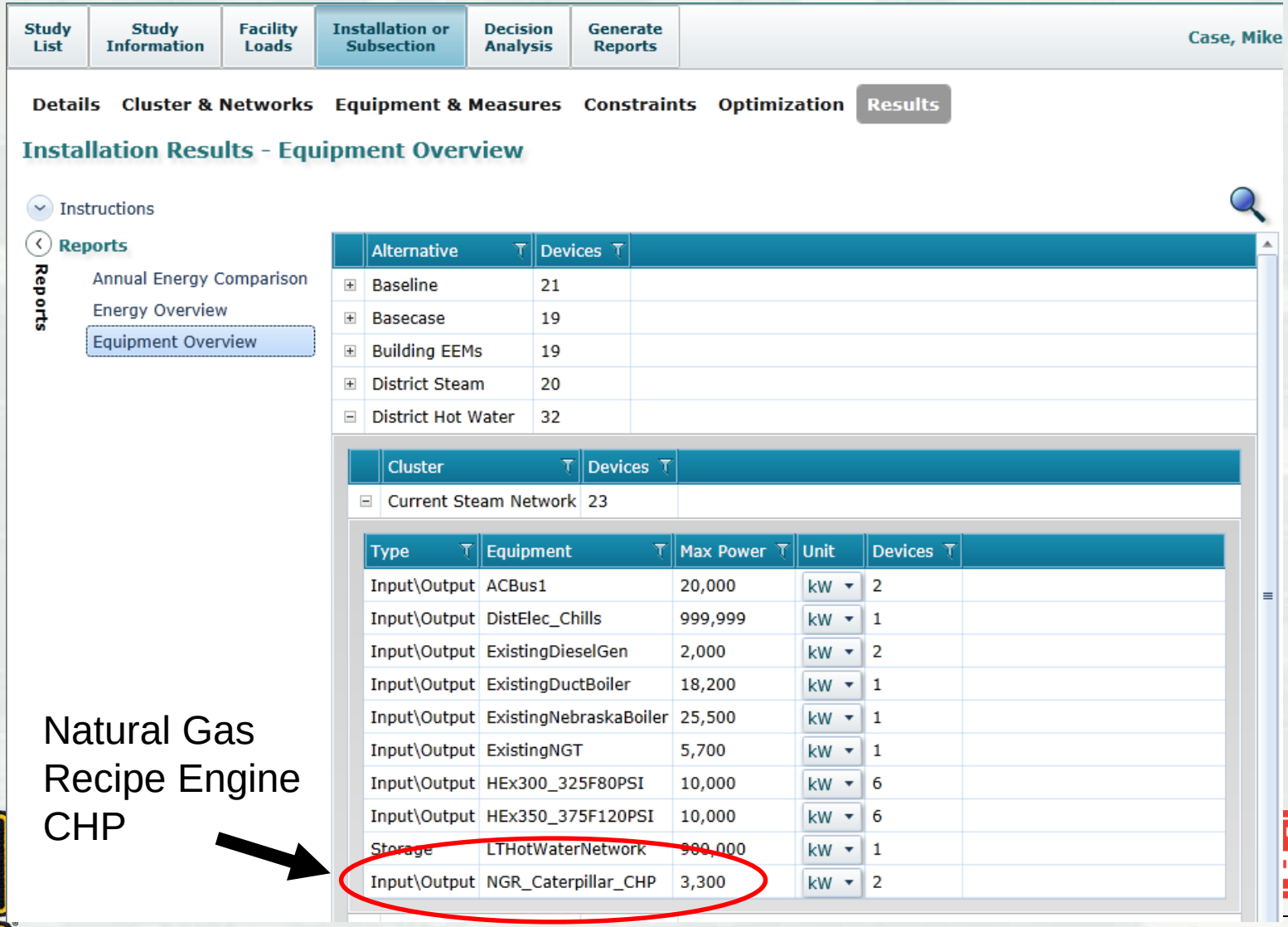
Cluster Results



Decision Support

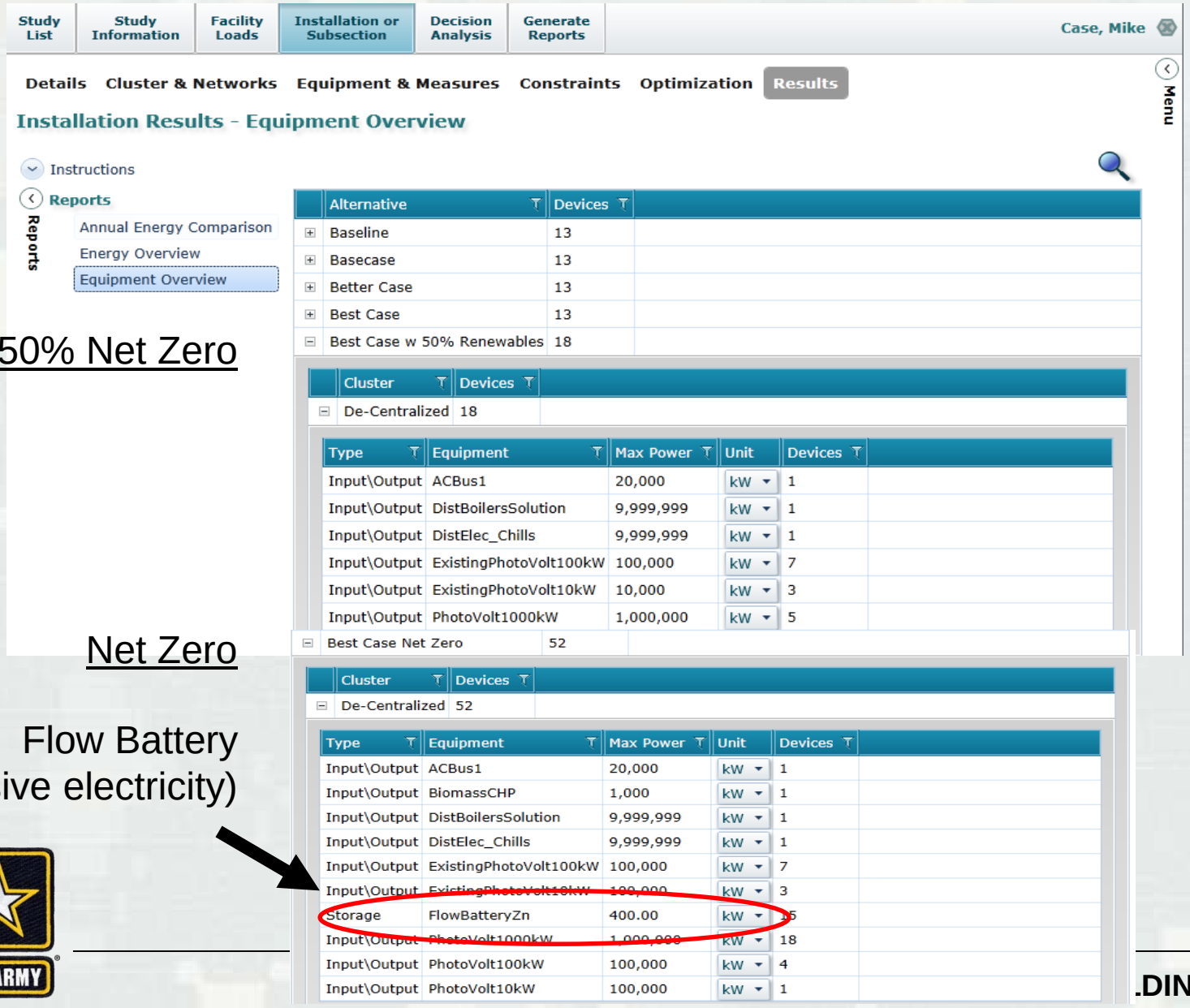


Cluster Results
Cold Climate



Natural Gas Recipe Engine CHP

Cluster Results - Warm Climate



50% Net Zero

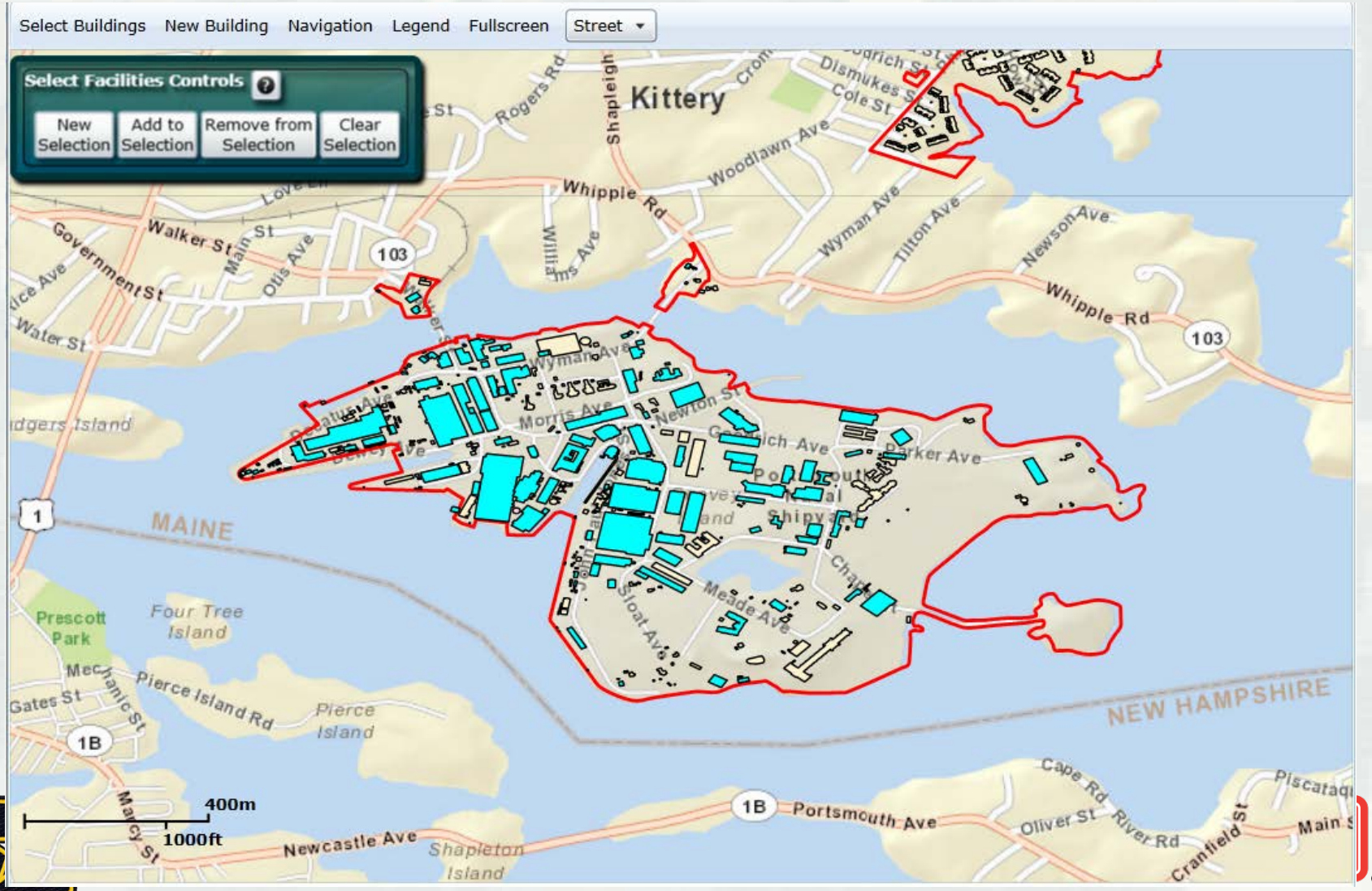
Net Zero

Flow Battery
(expensive electricity)

DECISION ANALYSIS FOR PORTSMOUTH NAVAL SHIPYARD (PNSY)

PNSY Aerial View

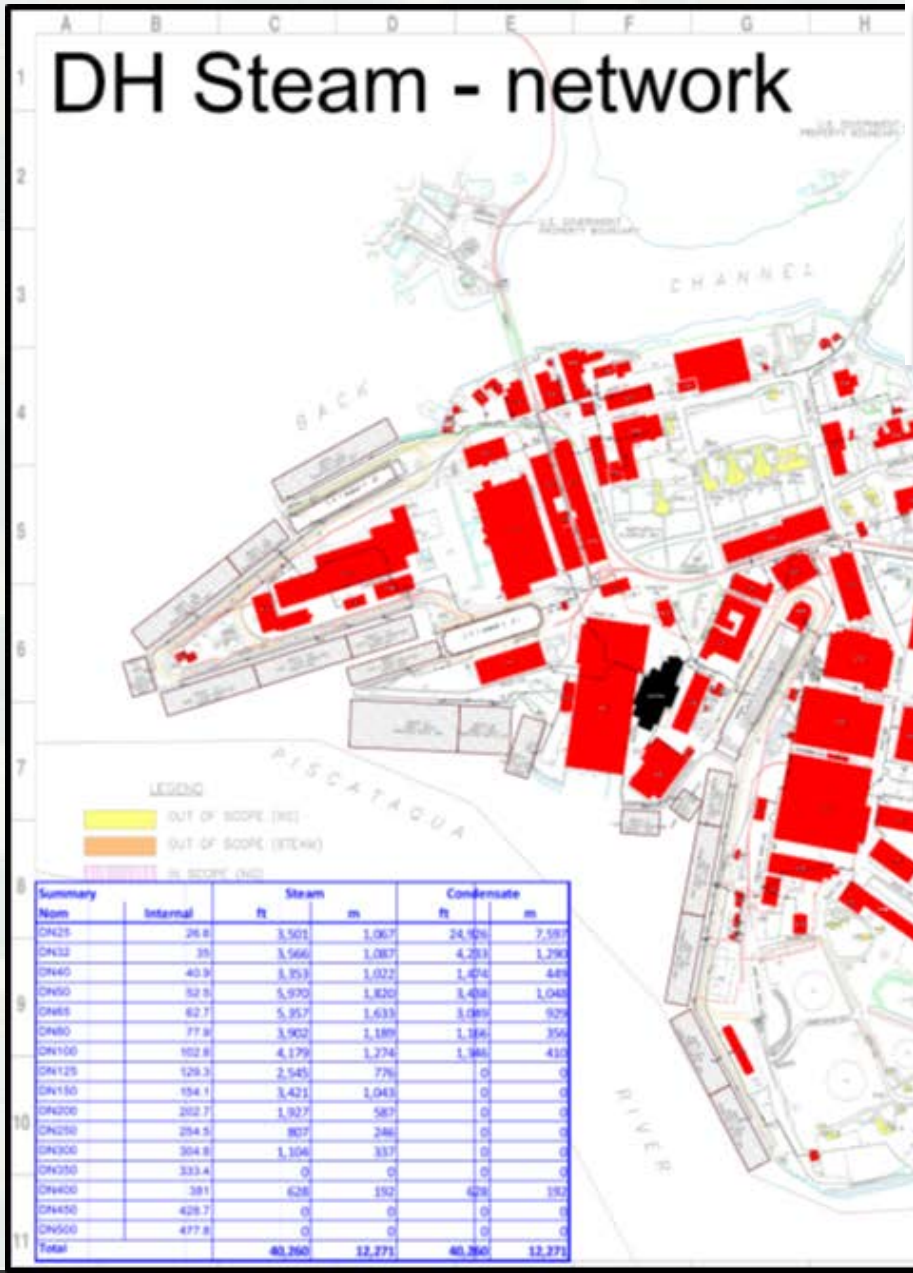
Building Representation in NZP



Description of Alternative Scenarios

- **1. Baseline**:
  - Existing buildings and central plant equipment is simulated.
- **2. Basecase**:
  - buildings with planned construction, renovation, and demolition. Existing central plant equipment provides a “status quo” used as a comparison for the remaining scenarios.
- **3. District Steam**:
  - buildings with a modern steam system. One existing natural gas turbine is replaced with two natural gas reciprocating engines with approximately half the electrical output capacity each.
- **4. District hot water and spot steam (District Hot Water)**:
  - buildings with a modern hot water system and spot steam generation to meet process loads. Central plant same as District Steam scenario.
- **5. Decentralized**:
  - buildings with decentralized boilers/furnaces and spot steam generation to meet process load. The same level of electrical backup is still required (15.4 MW for the installation, as in the existing central plant).
- **6. Net-Zero Fossil Fuel (Net-Zero FF)**:
  - buildings with a modern hot water system and lowest equivalent annual cost equipment to meet net zero fossil fuel goals. Only analyzed using the NZP tool.

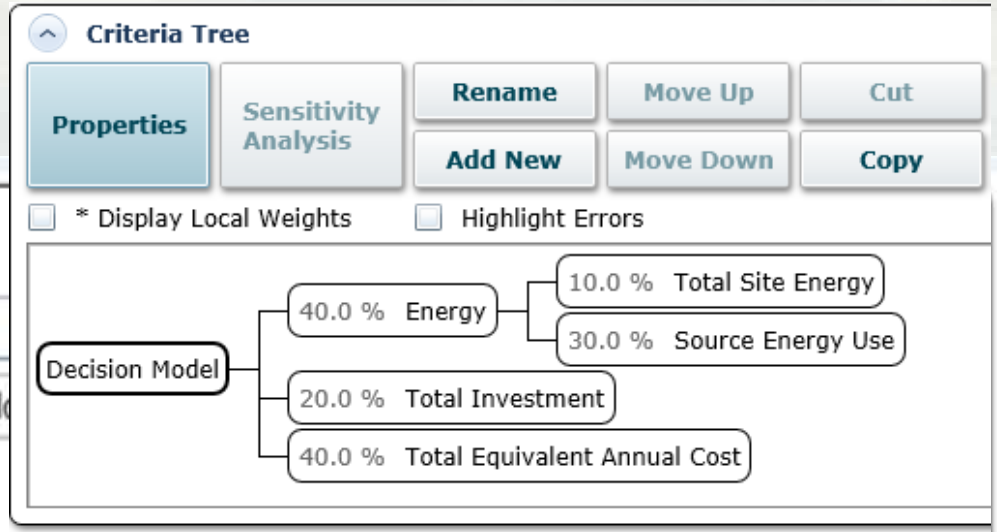
District System Network: *Sizing and Routing*



Current Steam...
N/A
Number of Buidlings: 108
Ground Coverage: 10,503,564 sqft
Total Electrical Load: 75,098,760 kWh/Yr
Total Space Heating Load: 48,935,636 kWh/Yr
Total DHW Load: 668,773 kWh/Yr
Total Cooling Load: 3,952,798 kWh/Yr
Total Heating Load Density: 4.72 kWh/Yr/sqft
Total Cooling Load Density: 0.38 kWh/Yr/sqft
Total Electrical Peak: 19,237 kWh/Yr
Total Cooling Peak: 11,542 kWh/Yr
Total Space Heating Peak: 109,141 kWh/Yr

Summary		Steam		Condensate	
Nom	Internal	ft	m	ft	m
DN25	26.8	3,501	1,067	24,926	7,597
DN32	35	3,566	1,087	4,253	1,296
DN40	40.9	3,353	1,022	1,474	449
DN50	52.5	5,970	1,820	3,458	1,054
DN65	62.7	5,357	1,633	3,089	929
DN80	77.9	3,902	1,189	1,164	356
DN100	102.8	4,179	1,274	1,366	416
DN125	129.3	2,545	776	0	0
DN150	154.1	3,421	1,043	0	0
DN200	202.7	1,927	587	0	0
DN250	254.5	807	246	0	0
DN300	304.8	1,106	337	0	0
DN350	333.4	0	0	0	0
DN400	381	628	192	628	192
DN450	428.7	0	0	0	0
DN500	477.8	0	0	0	0
Total		40,360	12,271	40,360	12,271

Decision Model



MCDA Model: **Portsmouth 2040**

Name Portsmouth 2040

Access Level Edit Model Structure, Value Func ights

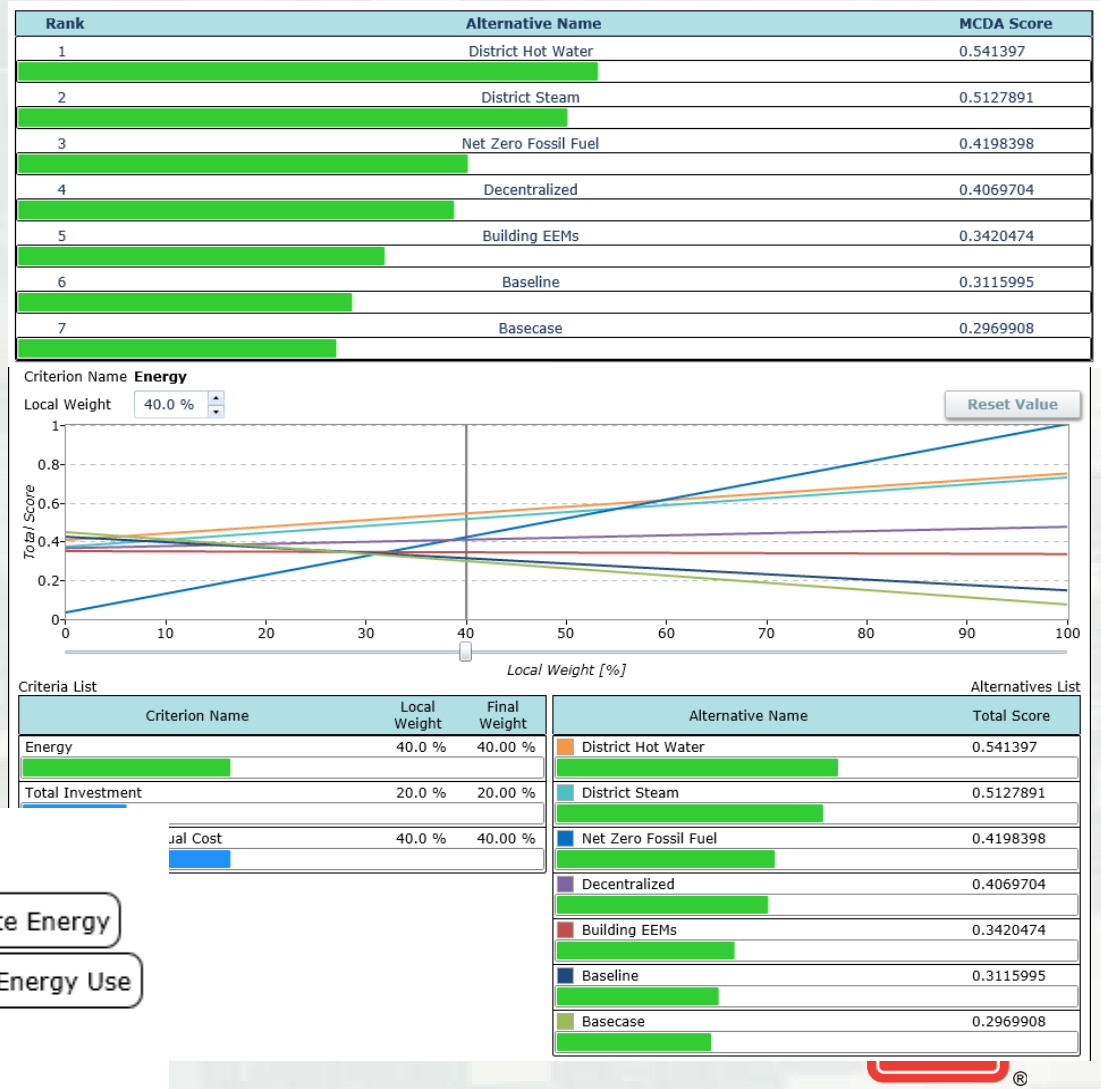
Rank	lternative Name	MCDA Score
1	Dist HW Reduced DD Loads	0.6854429
2	District Hot Water	0.5586616
3	District Steam	0.5157574
4	Net Zero Fossil Fuel	0.4435413
5	Decentralized	0.3951311
6	EEM Case for B	0.1326775
7	Baseli	
8	Basec	

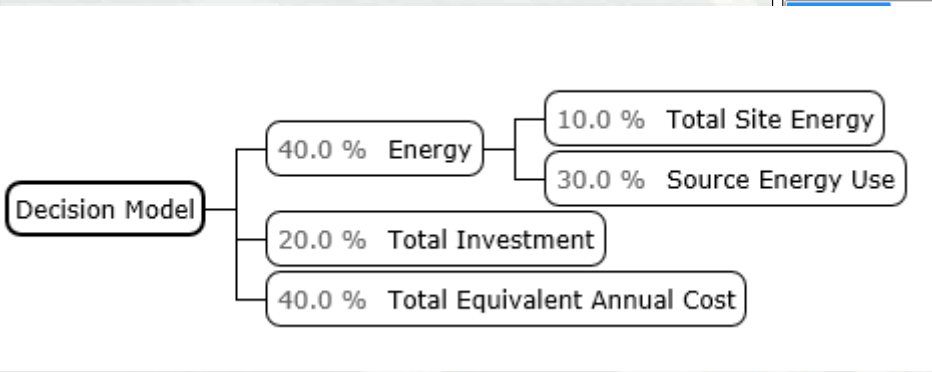
Centralized systems allow for higher energy security and flexibility

Decentralized attractive when done building by building and allows for “site energy” use reduction

Multi-Criteria Decision Analysis
Cool Weather Example

- Uses quantitative data from NZP models
- Qualitative data can be used (e.g. stakeholder opinions)
- Sensitivity analysis can be conducted on importance of different metrics.

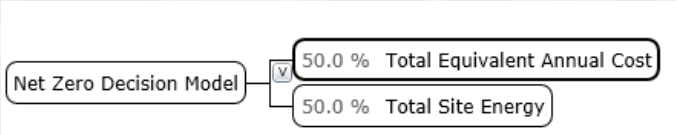


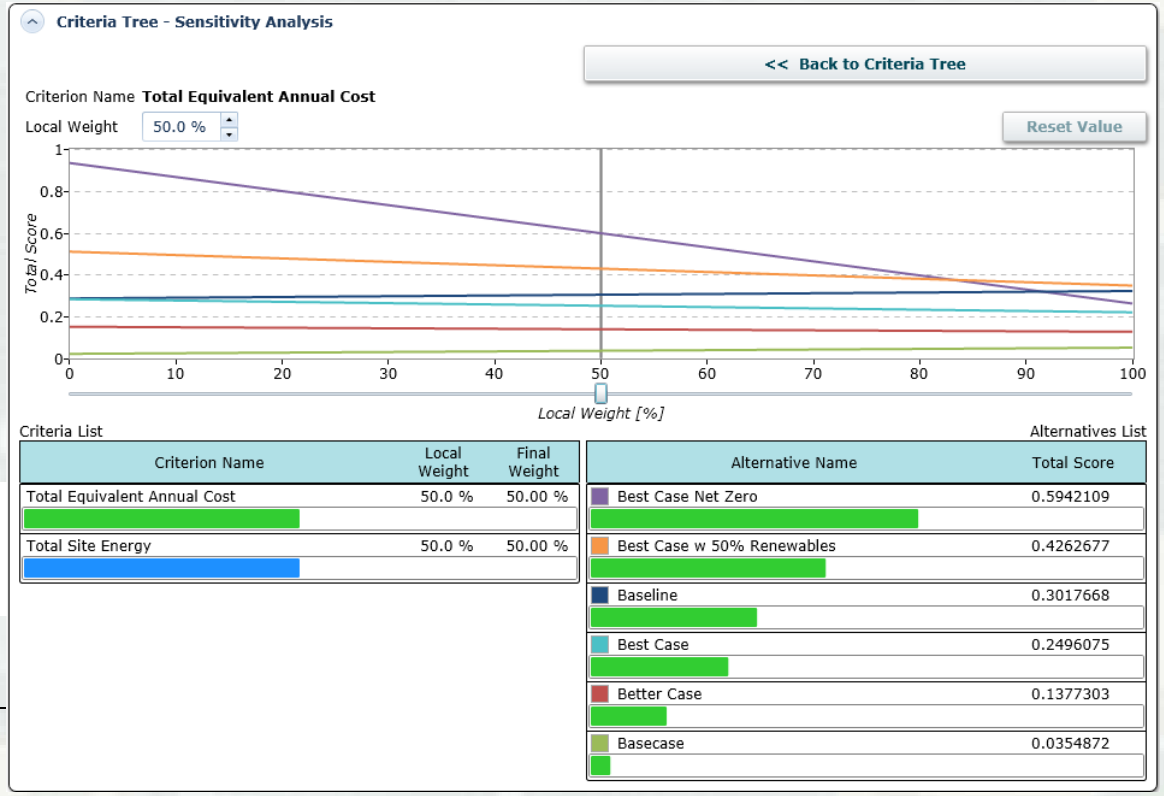


Multi-Criteria Decision Analysis
Warm Weather Example

- Net zero best choice based on equal weighting between energy and cost
- 50% new zero crosses to best at about 91% weighting on cost

Rank	Alternative Name	MCDA Score
1	Best Case Net Zero	0.5942109
2	Best Case w 50% Renewables	0.4262677
3	Baseline	0.3017668
4	Best Case	0.2496075
5	Better Case	0.1377303
6	Basecase	0.0354872





NZP Tool Conclusions

- Do not make short term decisions without a long term plan
- Simple Interface to POWERFUL underlying tools, i.e. EnergyPlus, AMPL, CPLEX, etc.
- NZP Tool analysis currently available through U.S. Army Corps of Engineers
- NZP Tool already follows the OSD Installation Energy Plans Memo

YouTube Live Demo

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

Conclusions

- Do not make short term decisions without a long term plan
- NZP Tool makes the data collection for energy and cost analysis faster and easier
- Simple Interface to POWERFUL underlying tools, i.e. EnergyPlus, AMPL, CPLEX, etc.