System Master PLanner / Net Zero Planner (SMPL/NZP) Tool Technical Capabilities

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BUILDING STRONG®

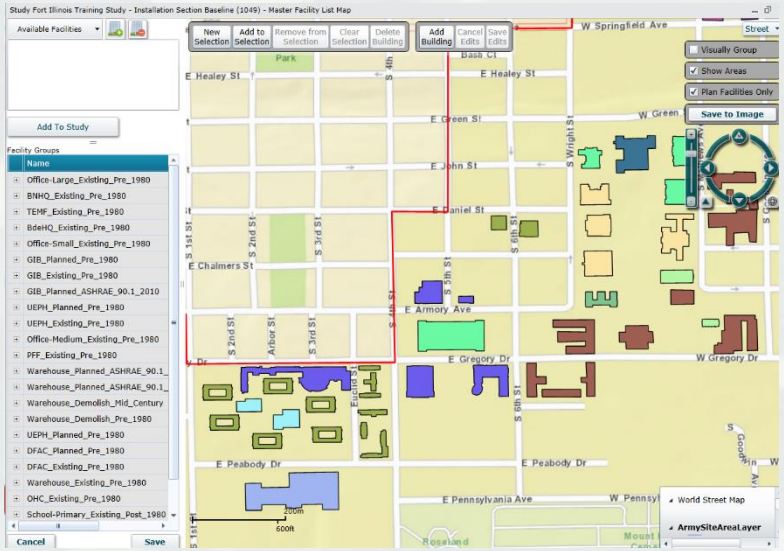
SMPL/NZP Supports Resilience Planning

- Critical electrical load (resilience)
- Redundant capacity planning for equipment
- Supports 14 day mission critical resource planning
- Maximum Investment cost
- Project life cycle costing

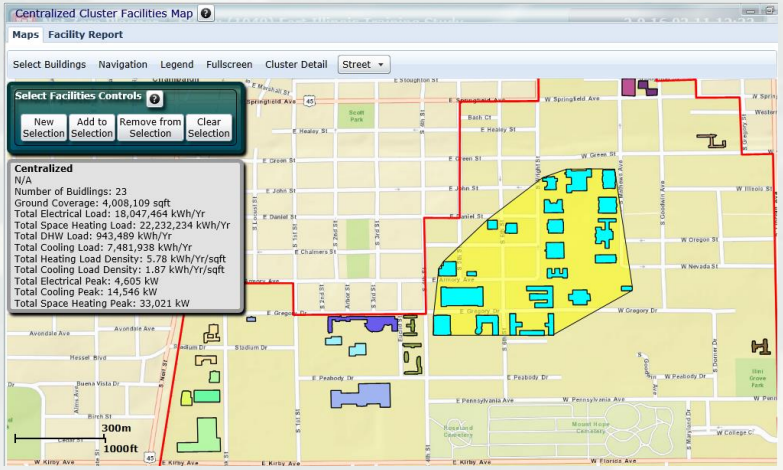
Today – will touch on load estimation, but spend more time on the supply side to support resilience.

SMPL/NZP Tool

- Web based tool that assists in installation-wide energy, water, and waste planning
- Estimates current and future energy **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

The SMPL/NZP Tool is used extensively by the U.S. Army Corps of Engineers

Fort Leonard Wood

West Point USMA

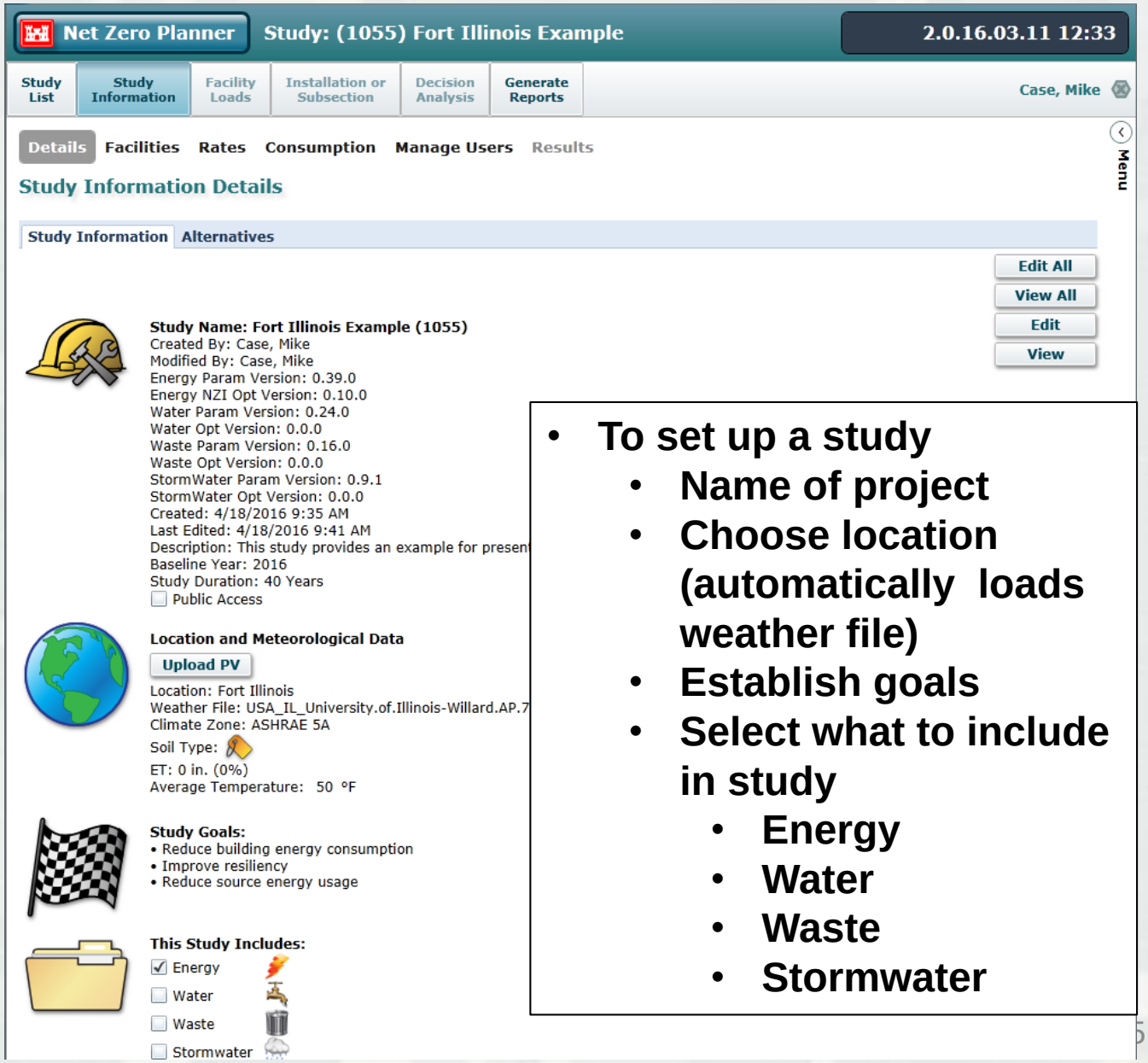
Waterways Experiment Station

Fort Hunter Liggett

Portsmouth Naval Shipyard

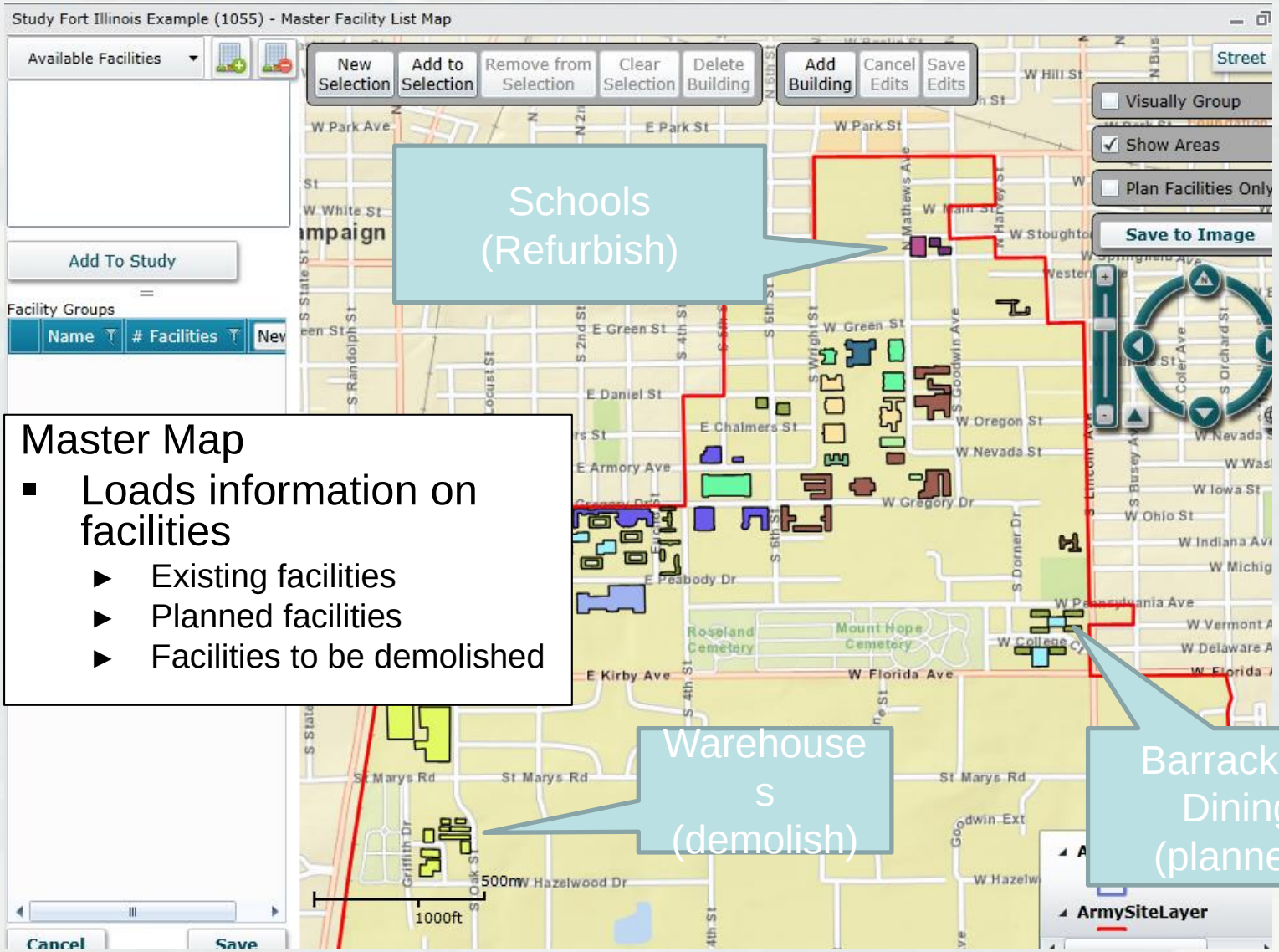
- Schofield Barracks
- Fort Hood
- Presidio at Monterey
- NASA Johnson Space Center
- Parks RFTA
- Lakenheath AFB, UK
- MCAS Iwakuni, Japan
- Over 60 studies 2015-2017

Setting up a Study

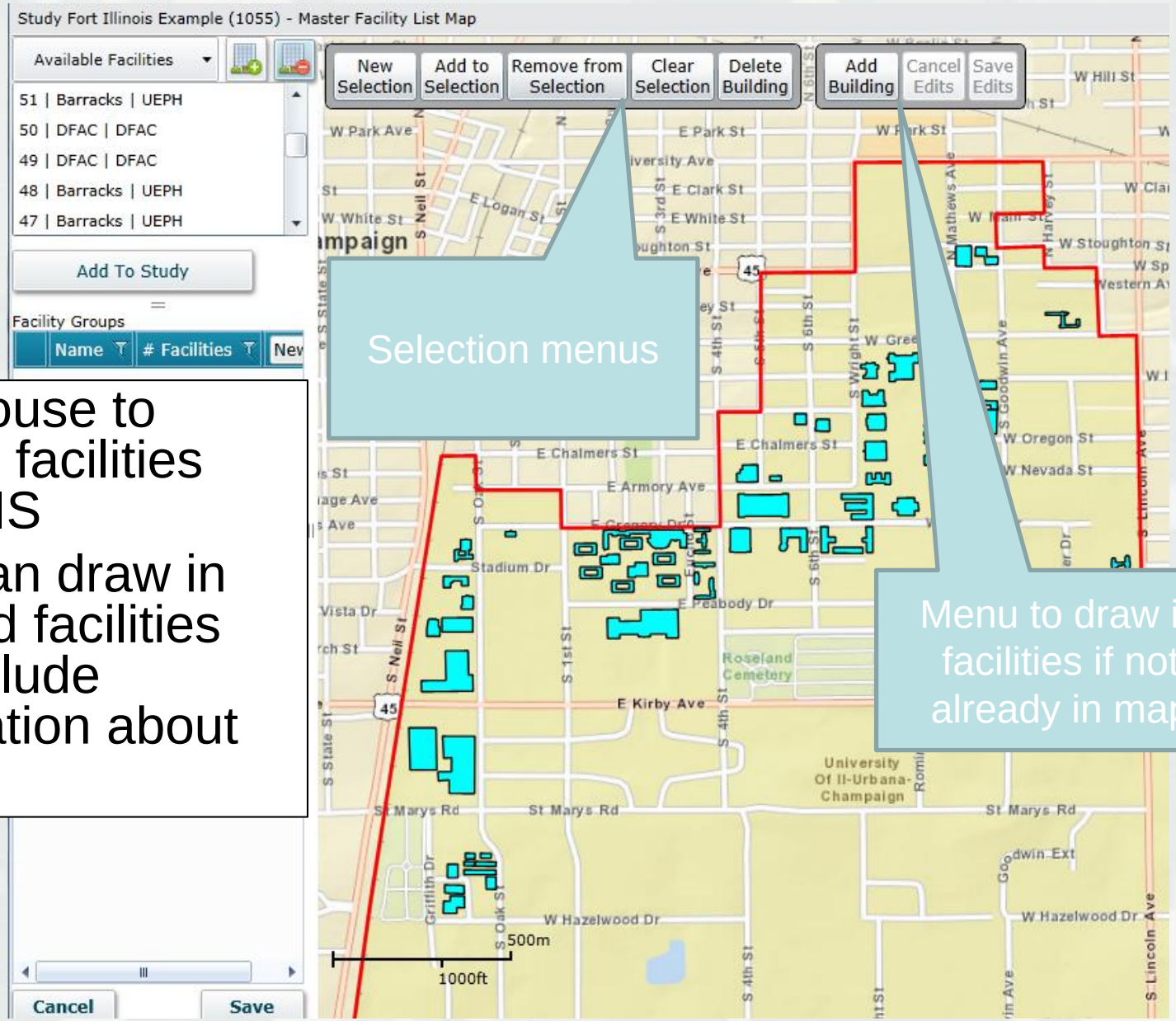


- To set up a study
  - Name of project
  - Choose location (automatically loads weather file)
  - Establish goals
  - Select what to include in study
    - Energy
    - Water
    - Waste
    - Stormwater

Begin with Geospatial Information System (GIS) Map of Installation



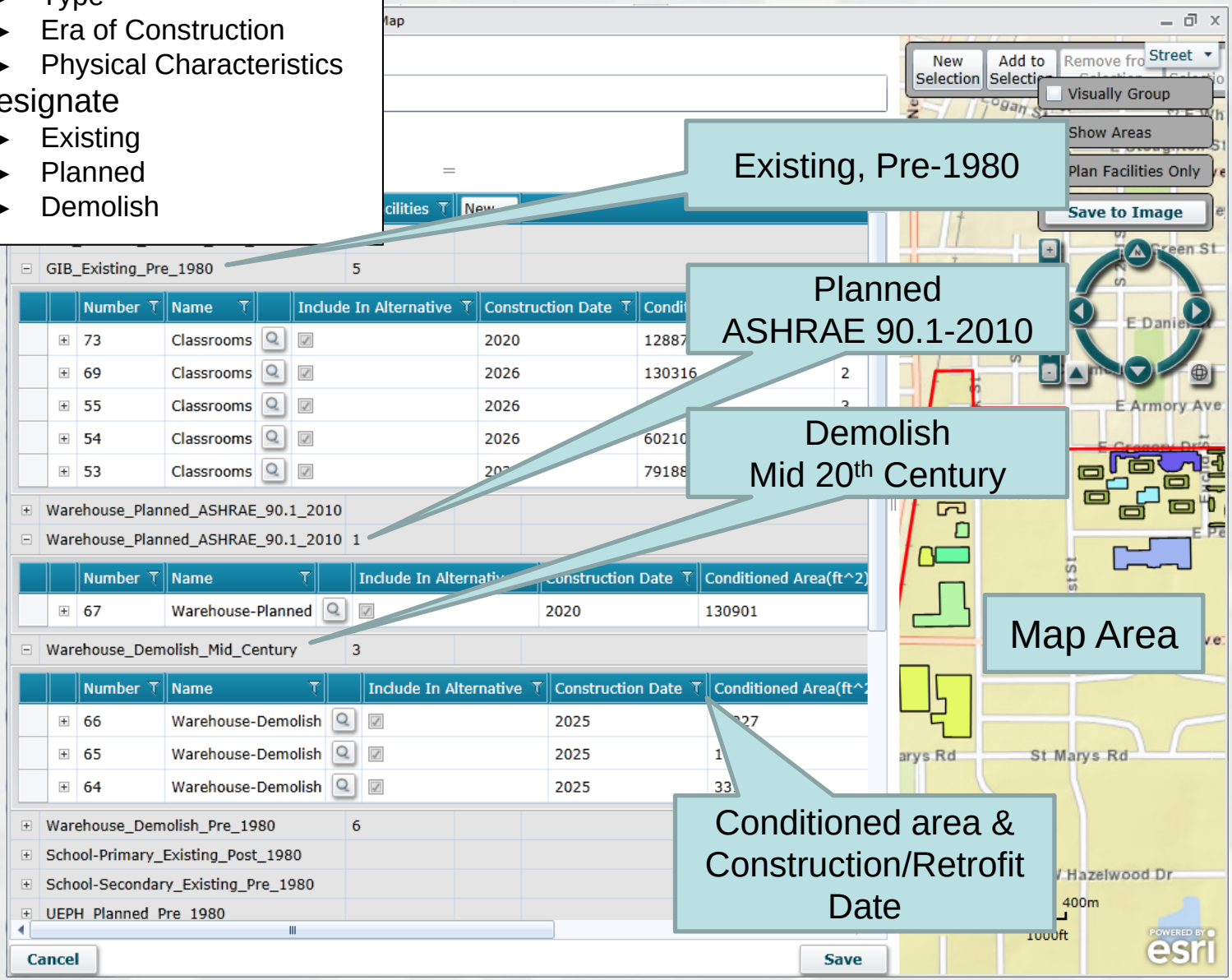
Select Facilities to Include in Study



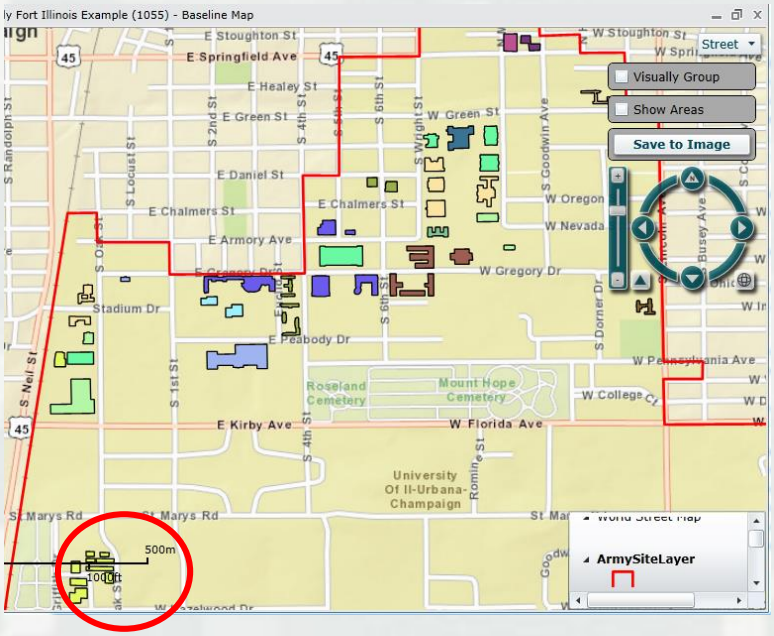
- Use mouse to choose facilities from GIS
- User can draw in planned facilities and include information about them

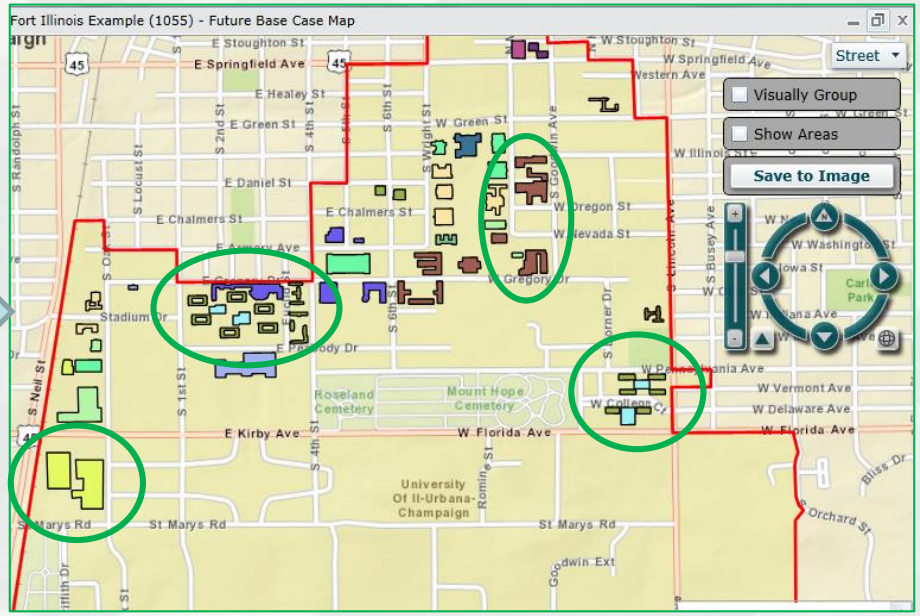
Group Facilities for Modeling

- Group by:
  - Type
  - Era of Construction
  - Physical Characteristics
- Designate
  - Existing
  - Planned
  - Demolish



Compare Baseline and Future Alternatives





Today

Future

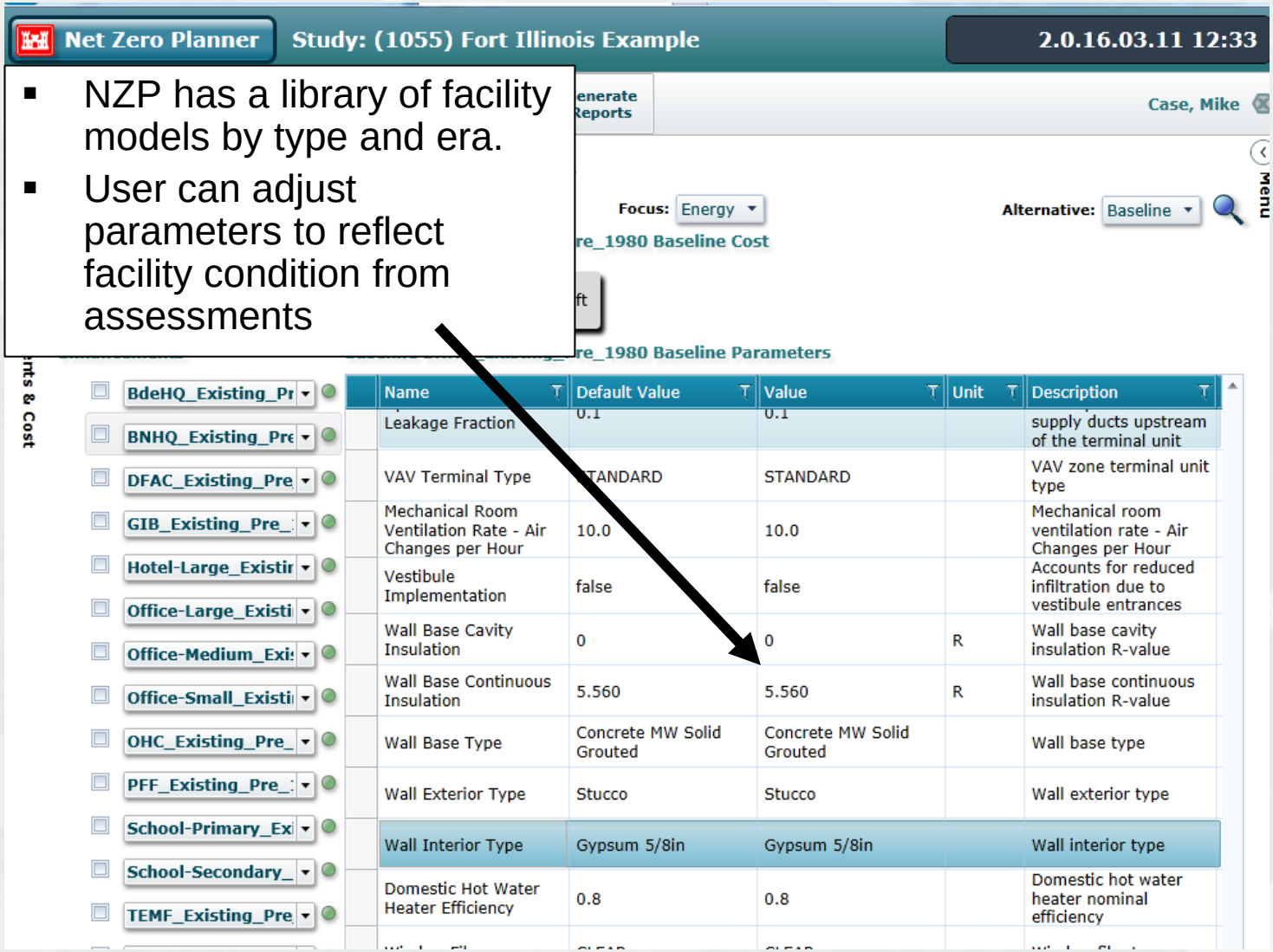
Demolish

Planned

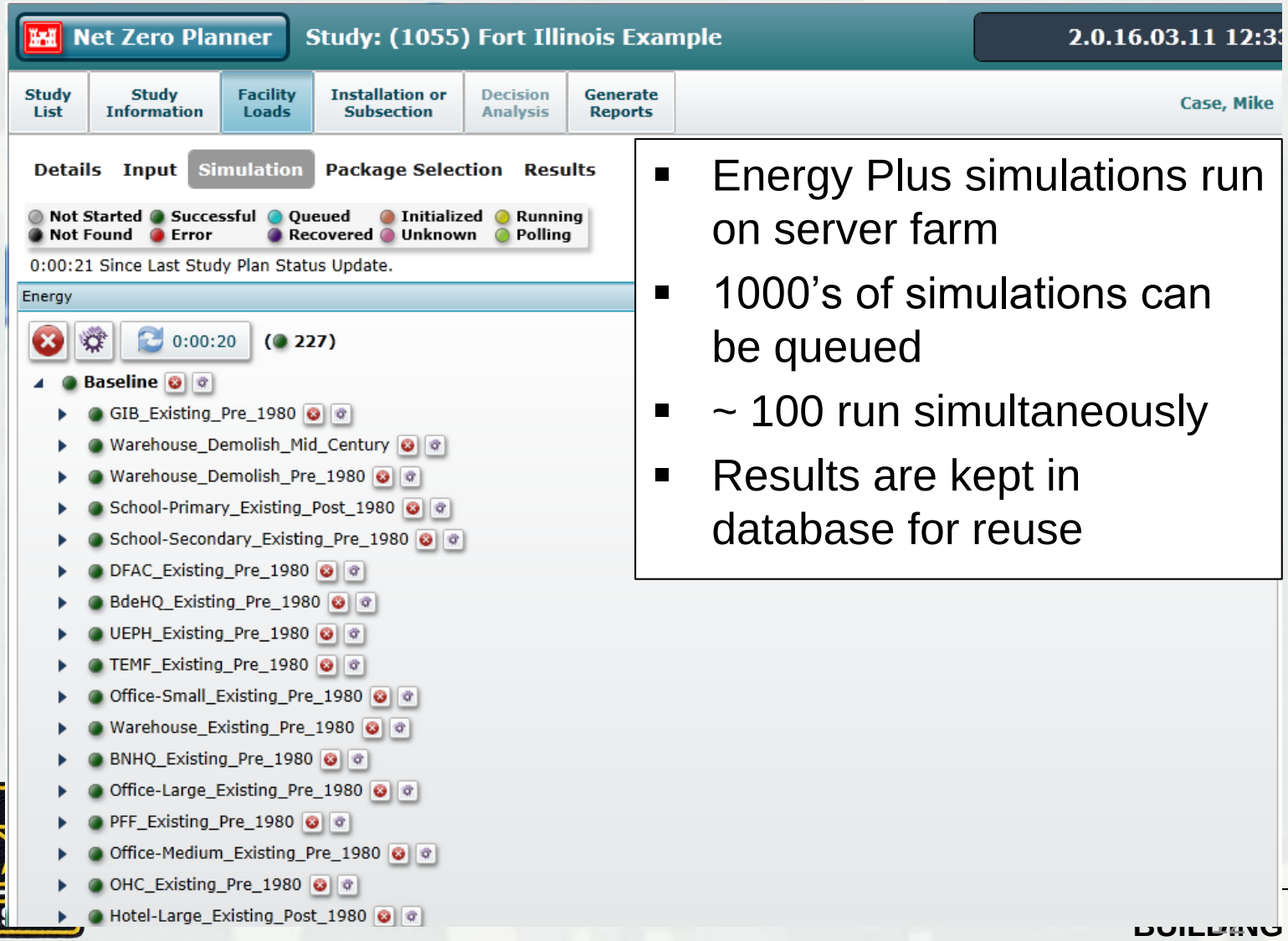
FACILITY LOAD ANALYSIS

Adjust Baseline Parameters

- NZP has a library of facility models by type and era.
- User can adjust parameters to reflect facility condition from assessments



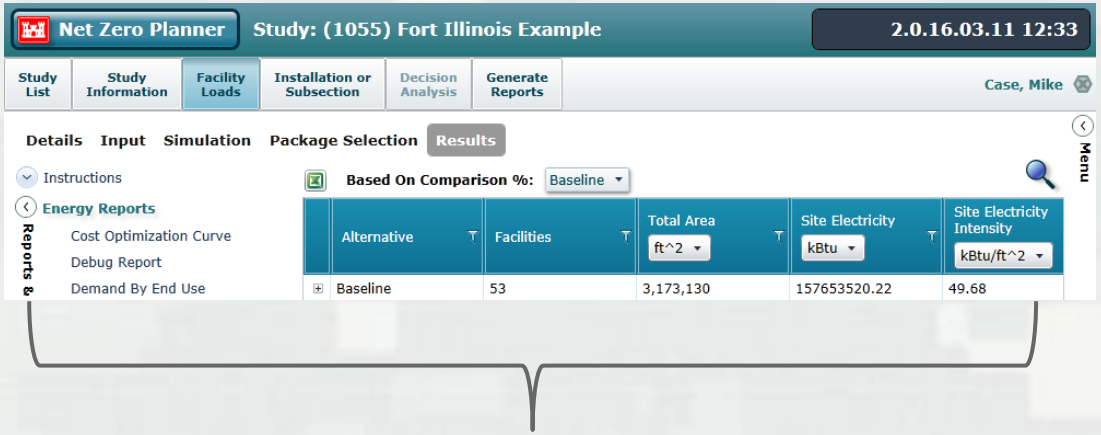
Simulate Facility Energy Use



- Energy Plus simulations run on server farm
- 1000's of simulations can be queued
- ~ 100 run simultaneously
- Results are kept in database for reuse

Calibrate Facility Simulation Models

- Use utility bills, meter data, assessments
- Use available data to get the best match between models and data.
- May or may not have individual facility meter data or sub-meter data

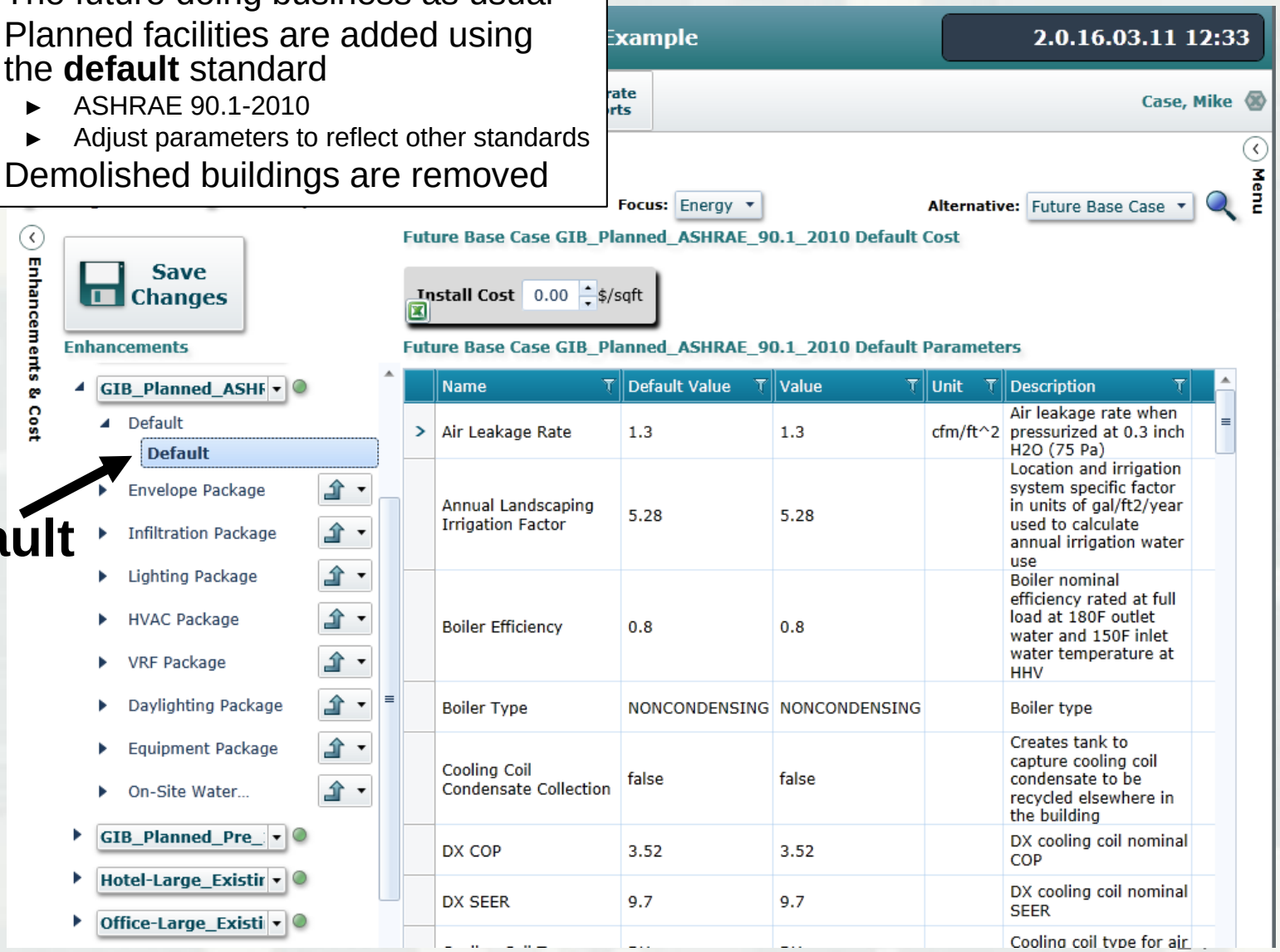


Alternative		Facilities	Total Area ft^2	Site Electricity kBtu	Site Electricity Intensity kBtu/ft^2	Site Gas kBtu	Site Gas Intensity kBtu/ft^2	Energy Cost $/year	Site Total Energy Intensity kBtu/ft^2	Site Total Energy kBtu
Baseline		53	3,173,130	157,653,520	49.68	239651548.5	75.53	6,382,882	125.21	397,305,069
	Facility Group	Facilities	Total Area	Electricity	Electricity Intensity	Gas	Gas Intensity	Energy Cost $/year	Total Energy Intensity	
	BdeHQ_Existing_Pre_1980	4	360,480	20,852,448	57.85	7846917	21.77	668,871	79.61	
	BNHQ_Existing_Pre_1980	6	398,928	16,249,537	40.73	11646591	29.19	561,901	69.93	
	DFAC_Existing_Pre_1980	2	52,840	6,432,737	121.74	15130832	286.35	299,796	408.09	
	GIB_Existing_Pre_1980	5	461,651	17,227,486	37.32	24341794	52.73	683,911	90.04	
	Hotel-Large_Existing_Post_1980	1	57,543	2,788,298	48.46	5129216	89.14	119,438	137.59	
	Office-Large_Existing_Pre_1980	1	71,515	4,157,125	58.13	2453794	34.31	139,885	92.44	
	Office-Medium_Existing_Pre_1980	5	346,102	22,881,788	66.11	21027850	60.76	825,269	126.87	
	Office-Small_Existing_Pre_1980	1	24,947	1,275,662	51.13	1320554	52.93	47,098	104.07	
	OHC_Existing_Pre_1980	1	43,195	1,611,323	37.30	769854	17.82	52,887	55.13	
	PFF_Existing_Pre_1980	2	181,807	18,549,704	102.03	41861984	230.26	851,490	332.28	
	School-Primary_Existing_Post_1980	1	47,610	2,157,551	45.32	4096707	86.05	93,359	131.36	
	School-Secondary_Existing_Pre_1980	1	110,247	5,757,781	52.23	9556974	89.41	241,235	141.63	
	TEMF_Existing_Pre_1980	5	691,205	24,413,830	35.32	67032496	96.98	1,208,441	132.30	
	UEPH_Existing_Pre_1980	8	172,912	10,670,726	61.71	14821994	85.72	421,738	147.43	
	Warehouse_Demolish_Mid_Century	3	63,602	1,142,644	17.97	6890930	108.34	84,158	126.31	
	Warehouse_Demolish_Pre_1980	6	64,974	1,089,581	16.77	3979373	61.25	61,195	78.02	
	Warehouse_Existing_Pre_1980	1	23,572	395,290	16.77	1443681	61.25	22,201	78.02	

Calibrate baselines against Energy Use Intensities (EUI) by Facility Group

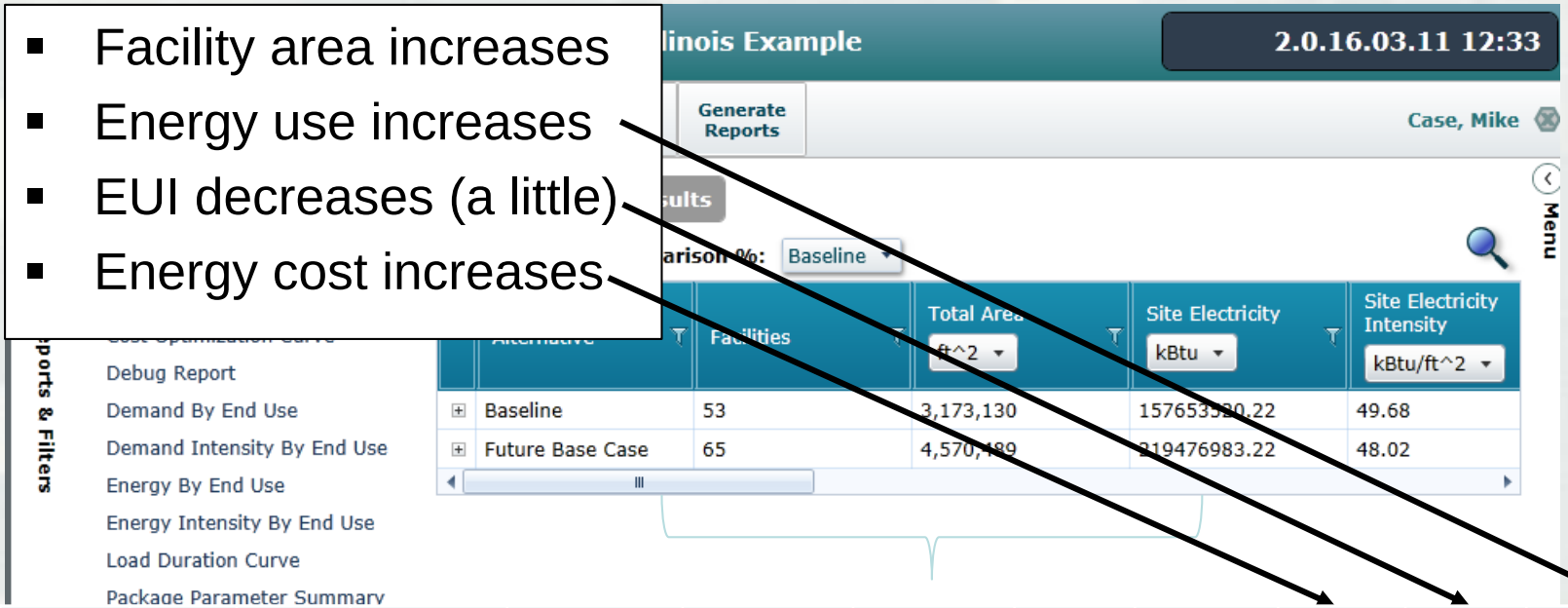
Build the Base Case Using Simulation

- The future doing business as usual
- Planned facilities are added using the **default** standard
  - ASHRAE 90.1-2010
  - Adjust parameters to reflect other standards
- Demolished buildings are removed



Base Case vs. Baseline

- Facility area increases
- Energy use increases
- EUI decreases (a little)
- Energy cost increases



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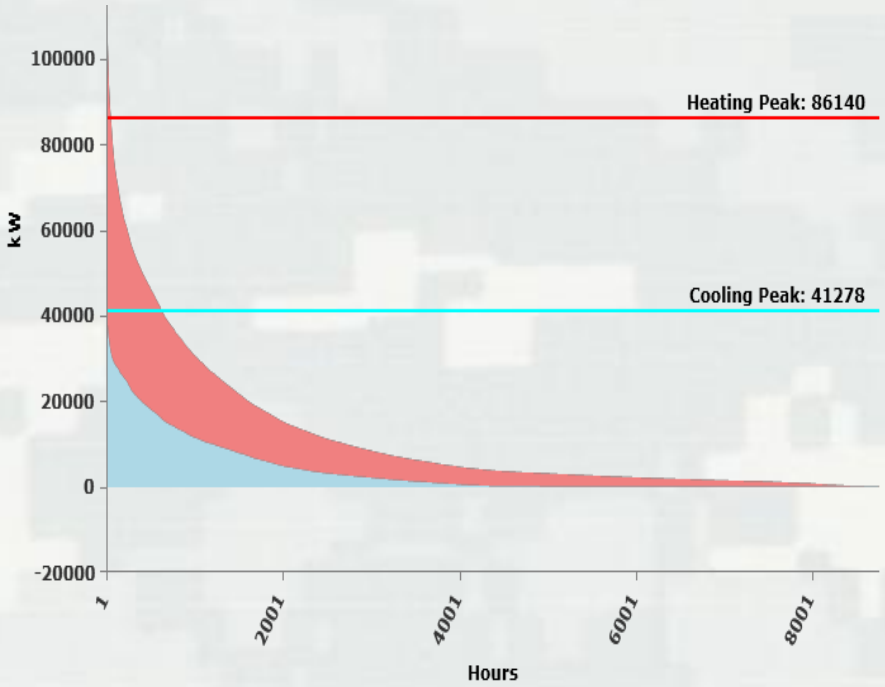
Baseline	53	3,173,130	157,653,520	49.68	0	239,651,549	75.53	0	6,382,882	125	397,305,069
Future Base Case	65	4,570,489	219,476,983	48.02	-39	320,381,506	70.10	-34	8,788,496	118	539,858,489

Base Case Load Duration Curves

- Use for resilience planning
- Used to determine base loading & peaking requirements
- Shows combined loads of all facilities in the study
- Different types of facilities experience peak load as different times



Heating and Cooling Loads

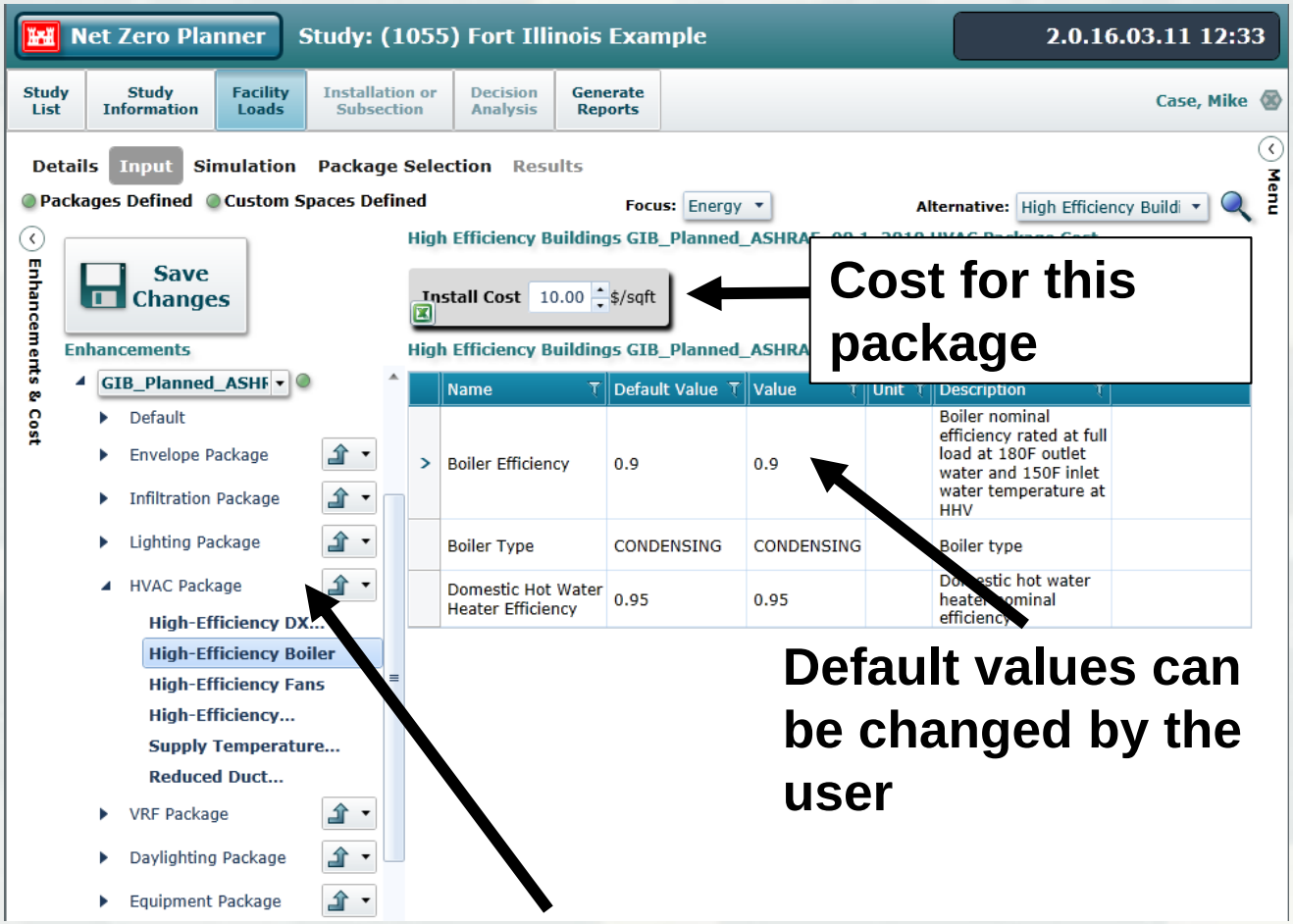
Electrical Power Loads

Create Alternative Scenario(s)

- For planned buildings, can simulate measures more efficient than the standard
- For existing buildings due for a major retrofit, can simulate deep energy retrofit measures
- For the rest, look at typical minor improvements, ESCOs, etc.
- As many alternatives as you want to consider
- Different funding levels and energy prices – tool gives an opportunity to ask – “What if?”

SMPL/NZP Automatically Simulates "Packages" of Efficiency Measures

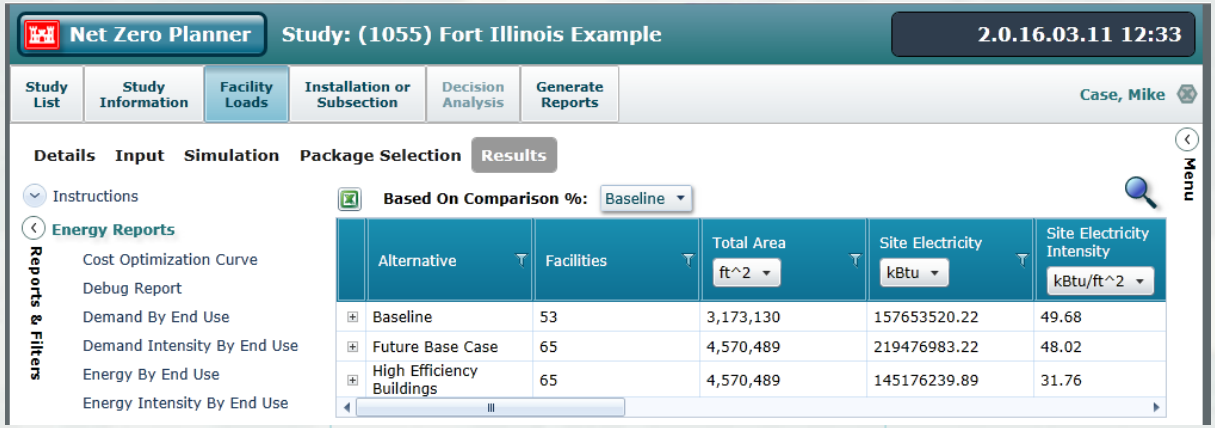
- Measures vary by facility type and climate zone
- Costs per package based on delta from standard
- User can change parameters and costs to reflect higher or lower efficiencies
- Costs and efficiency effects are cumulative as packages are combined



Results - High Efficiency Facilities Alternative

Despite facility area increase of 44%:

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



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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

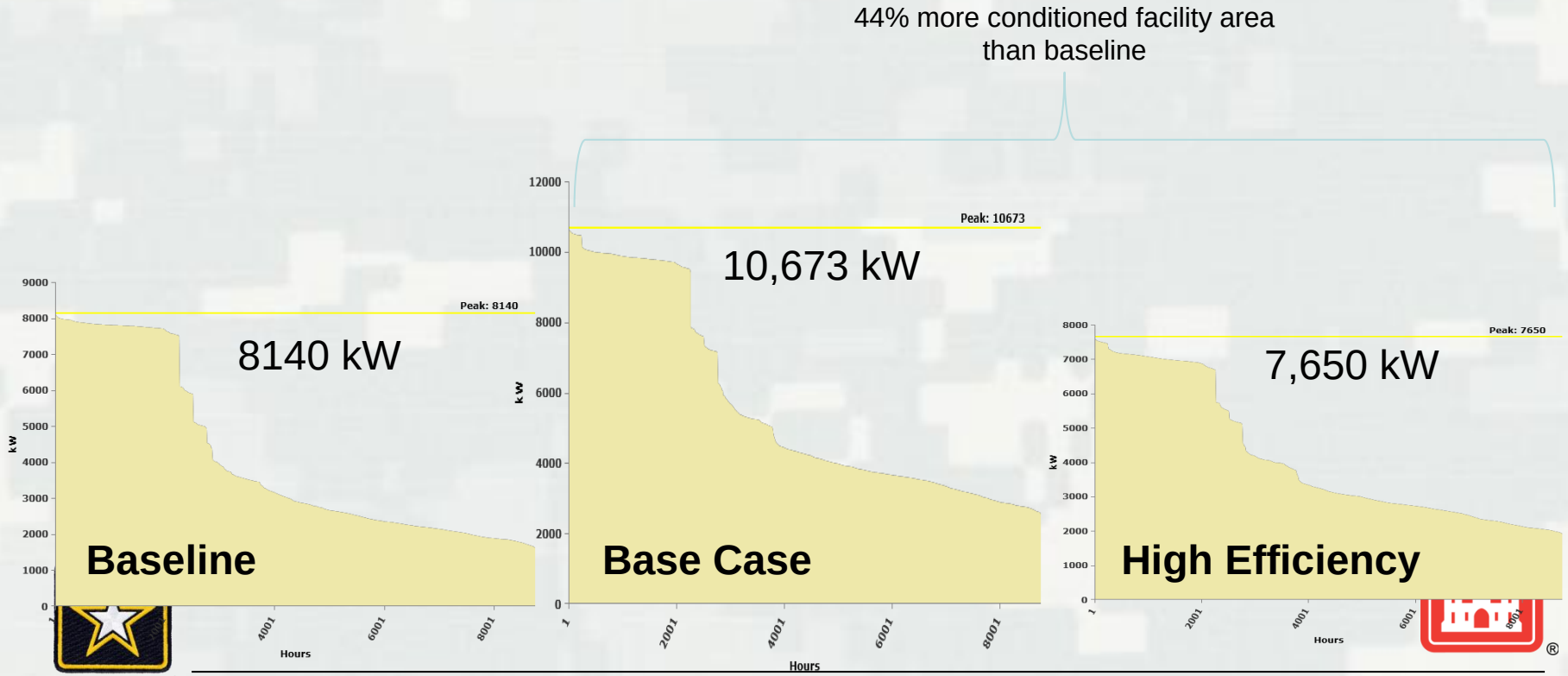
investment

life cycle cost decreases

energy use decreases

Compare Electrical Load Duration Curves

- Many Installations are constrained by their connection to the commercial grid
- Resilience is improved by lowering electrical power peak loads



Curves y-axes scaled to be approximately equivalent

INSTALLATION ENERGY CONVERSION AND DISTRIBUTION: CLUSTER ANALYSIS

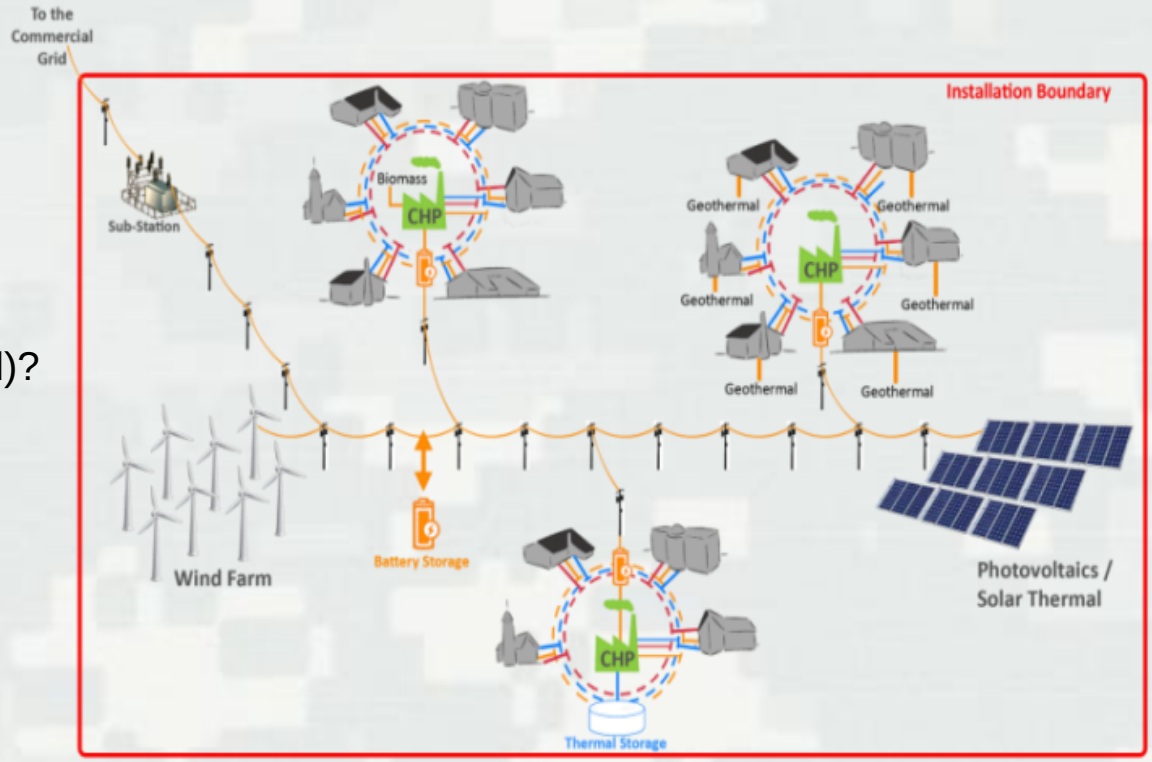
Optimizing Supply and Distribution

Loads were determined in the previous section

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

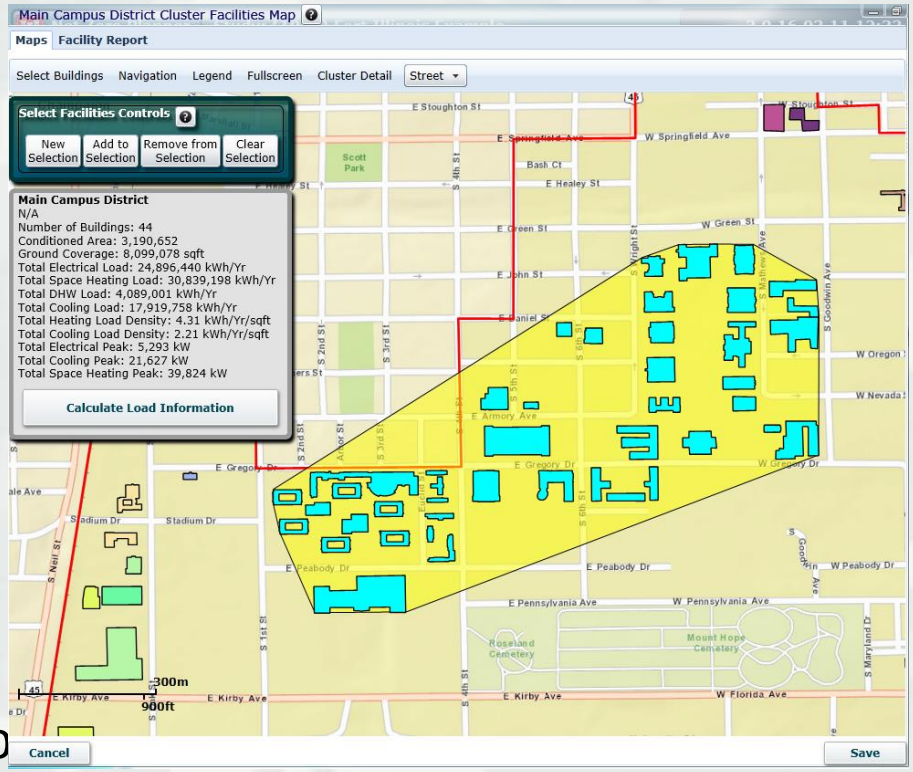
- How long can the community run using on-site generation?
- Distribution
  - Electrical Power Grid?
  - Decentralized Heating/ Cooling (Natural Gas Grid)?
  - District Heating/Cooling?
- Storage
  - Thermal
  - Electrical
- Supply
  - Renewables?
    - Solar
    - Wind
    - Biomass
    - Etc.

  Fossil Fuels?



The SMPL/NZP Tool Optimizes "Clusters" for Supply Options

- A cluster is a group of facilities and systems selected by the user for supply options
- **No Technology bias, use data and costs for optimization**
- SMPL-NZP Tool calculates loads and uses a database of distribution, supply, and storage options
- Optimization uses Mixed-Integer Linear Programming (MILP using AMPL-CPLEX) to meet the loads at the lowest cost.



Technologies Considered

- Boilers (central & distributed)
- Chillers (central & distributed)
- Engines (Natural Gas, Diesel)
- Gas Turbines (inc. Cogen)
- Steam Turbines
- Combined Cycle Turbines
- Solar Photovoltaic
- Wind Turbines
- Biomass (incl. Cogen)
- Organic Rankine Cycle
- Waste to energy
- Various sizes of above

- High temperature hot water district
- Low temperature hot water district
- Steam district
- Hot Water Storage
- Chilled Water Storage
- Electrical Storage

86 combinations of above technologies in various sizes are in the tool.

The User can add technologies as desired:

- Capacity (size)
- Conversion efficiency
- Installation cost
- Maintenance costs
- Losses (for storage and networks.

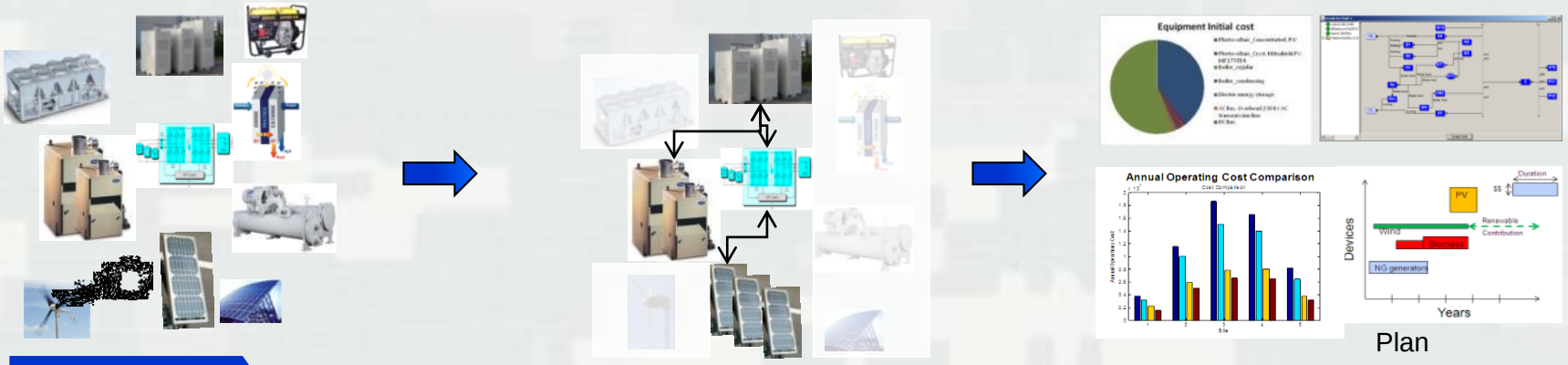
Set Constraints

Constraints include:

- Critical electrical load => resilience
- Maximum Carbon Footprint
- Excess generated electrical power can be exported (Net Metering) - (yes/no)
- Redundancy (e.g., n + 1)
- Maximum Investment cost
- Maximum available combustibles (for waste to energy)
- Project lifetime

NZI Optimization Tool (NZI-Opt)

NZI-Opt is a module of SMPL/NZP 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

Plan

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

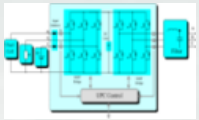
Photovoltaic

Absorption Chiller

Gas Boiler

Organic Rankine Cycle

Diesel Generator



AC Bus

Fuel Cell

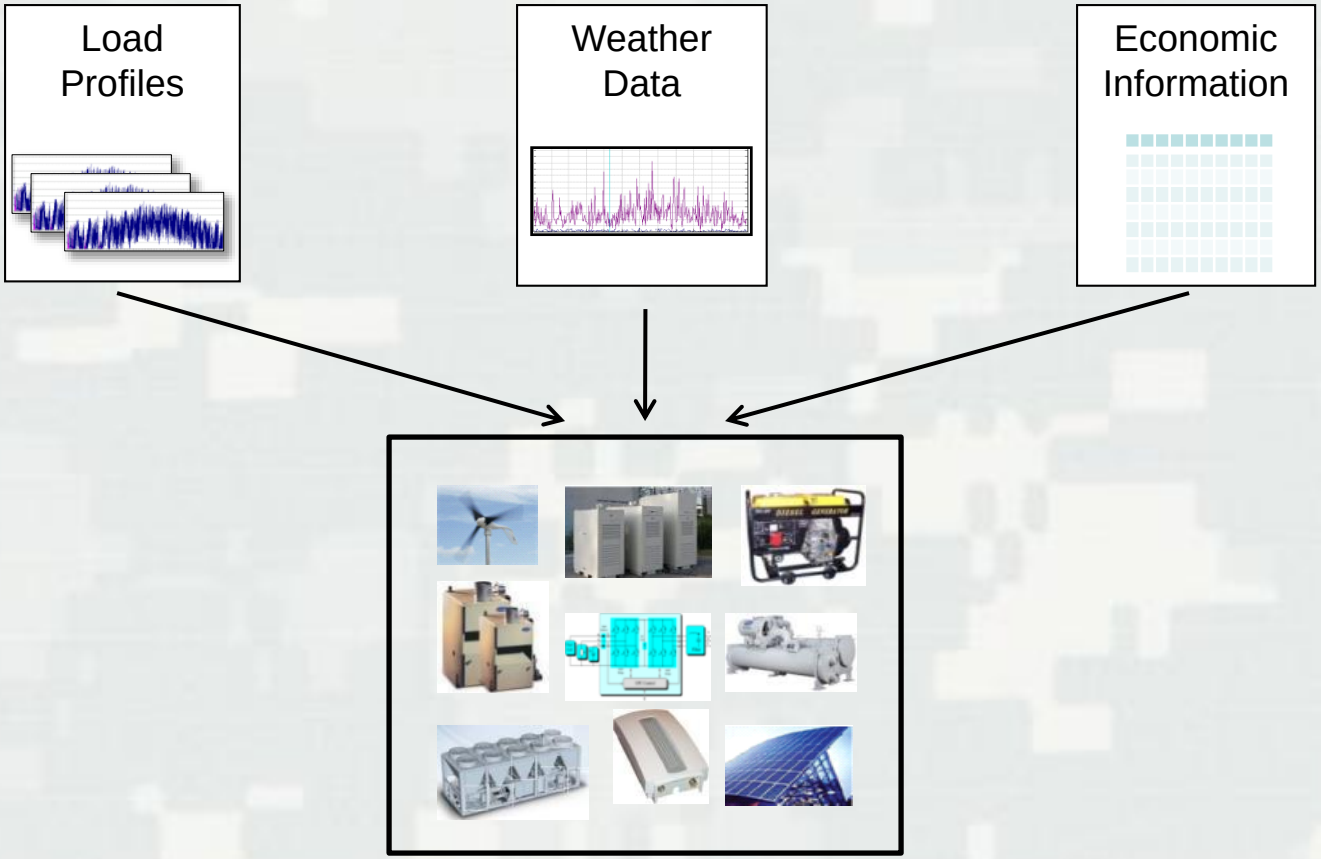
Wind Turbine

Gas Turbine

Electric Heater

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.

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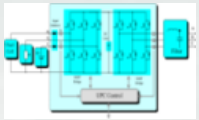

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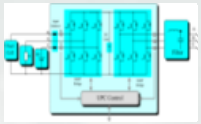
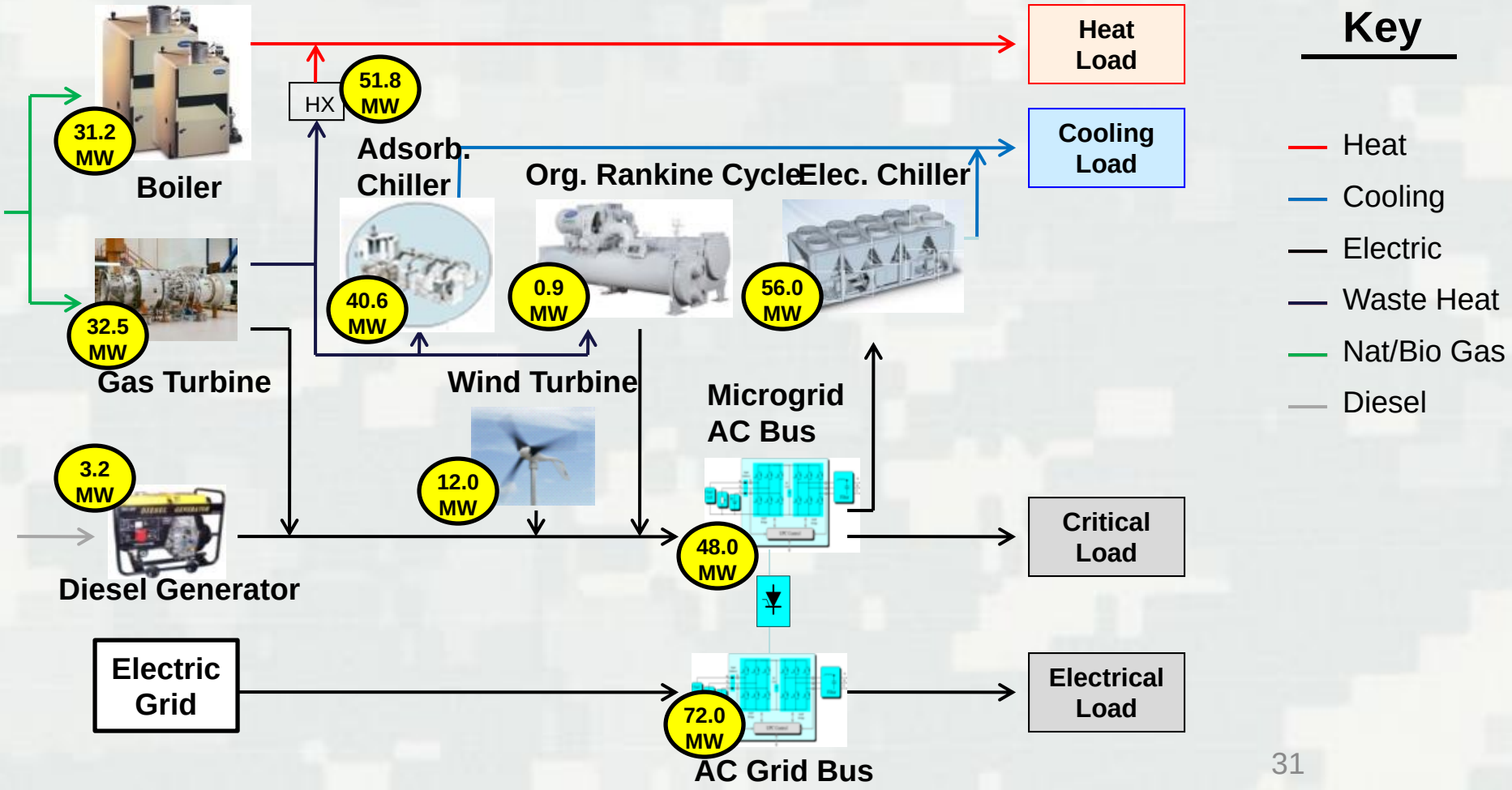
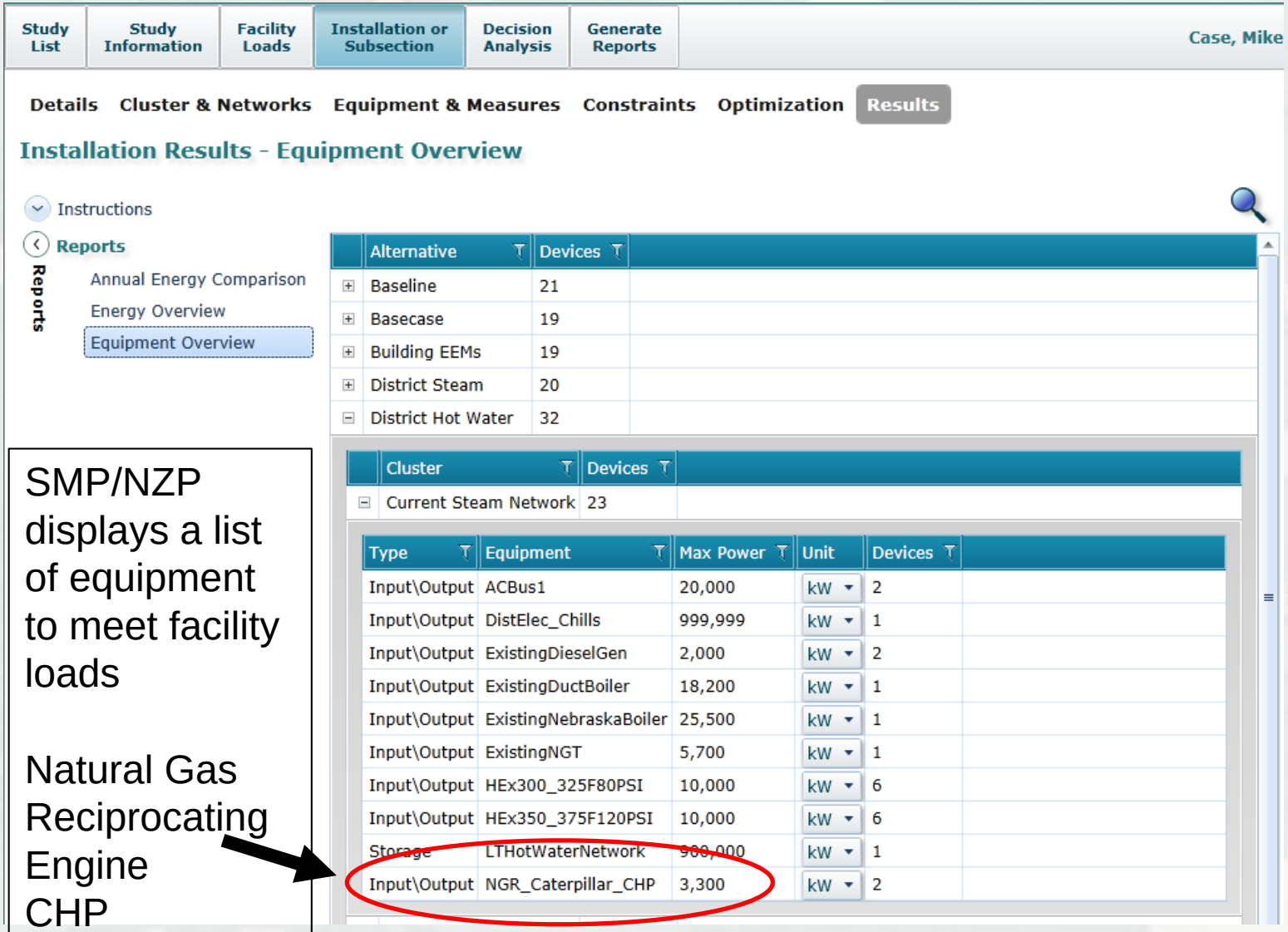


Sizing the Supply Equipment

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



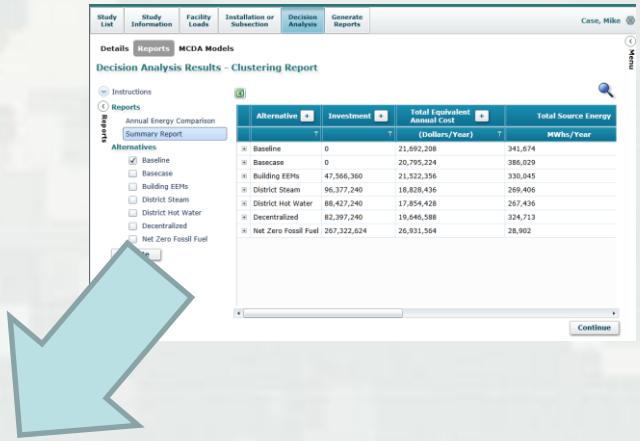
SMP/NZP displays a list of equipment to meet facility loads

Natural Gas Reciprocating Engine CHP

DECISION SUPPORT

Decision Support Example

- SMPL/NZP produces an “analysis of alternatives” decision matrix
- Includes energy consumption, investment, and data for LCC and Simple payback
- In this example, converting district steam to hot water is the most LCC effective alternative.



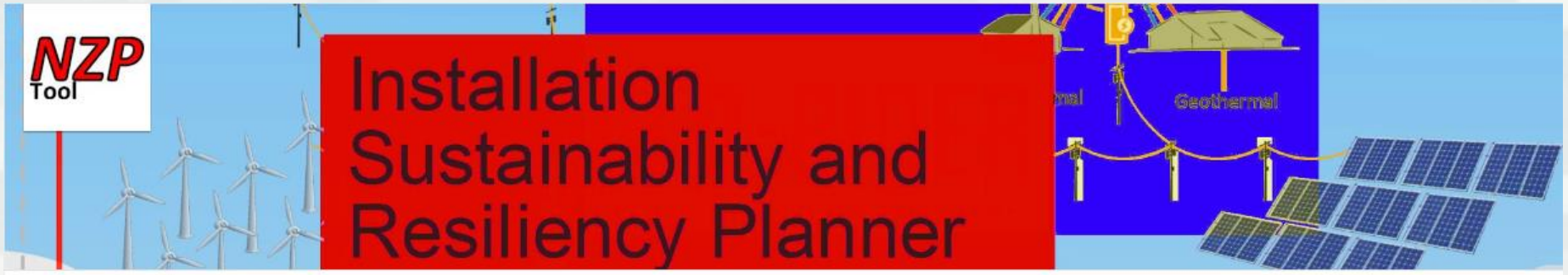
	SI Units NZP Energy (MWh/yr)							
Scenarios	Total Fossil Fuel + Biomass Fuel	Total Electricity	Total Site Energy	Total Source Energy	% Source Energy Reduction from Baseline	Investment $	Life Cycle Cost (Disc Rate = 3%)	Simple Payback Yrs
Baseline	258,810	23,228	282,038	348,550	0%			
Basecase	259,424	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

More on Decision Support Tomorrow!

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

- The SMPL/NZP tool provide a simple Interface to POWERFUL underlying tools, i.e. EnergyPlus, AMPL, CPLEX, etc.
- SMPL/NZP Tool analysis and training currently available through U.S. Army Corps of Engineers
- ERDC-CERL also has a Cooperative Research and Development Agreement with Big Ladder Software. *https://bigladdersoftware.com*

Questions?

Michael.p.case@usace.army.mil

Backup Slides

U.S. Office of Secretary of Defense Installation Energy Plan Guidance, March 31, 2016

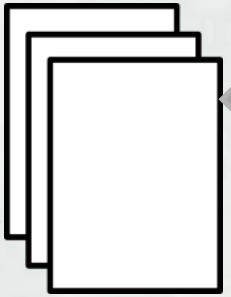
SMPL/NZP Tool directly supports Phases 1-3 and 6. It provides supporting data for phases 4 and 5.

- ✓ Phase 1: Identify the team, tasks, deliverables, and goals
- ✓ Phase 2: Establish baseline and future base case
- ✓ Phase 3: Establish alternative scenarios and analyze gaps
- Phase 4: Develop and sequence projects and activities
- Phase 5: Assemble review and finalize document
- ✓ Phase 6: Execution and maintenance of the Installation Energy Plan (allows iteration on the plan due to unforeseen circumstances)

SMPL-NZP Tool Process in a web based tool

Phase 1:
Establish Planning Goals

Phase 2:
Establish Baseline and Future Base Case

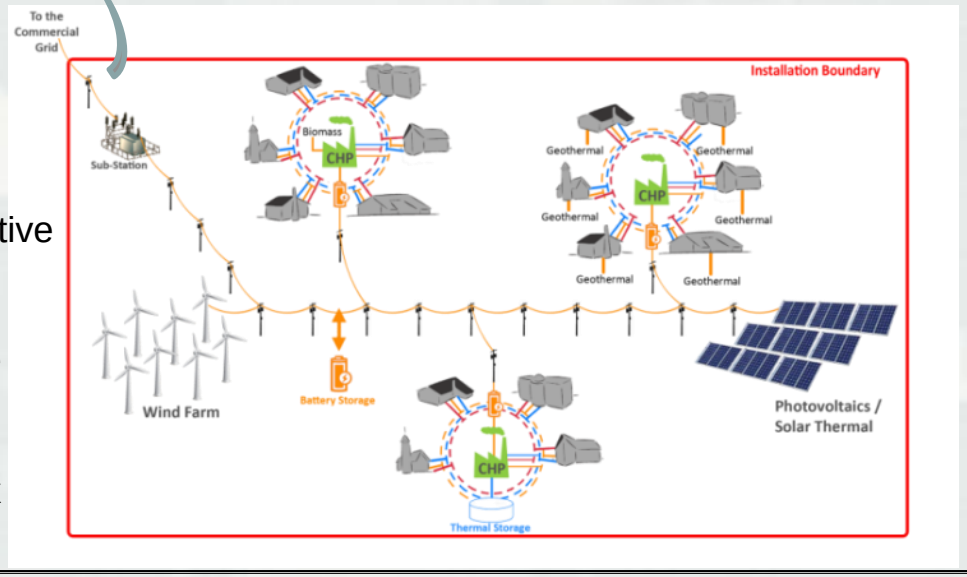


Phase 3:
Analyze alternative scenarios

Optimize Supply and Distribution System Mix

Optimize Building Energy Efficiency

Iterate over Building Measures



Phases 4 & 5:
Produce & Finalize Integrated Plan Documents

Phase 6:
Maintenance of IEP

Execute, Track, Measure

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

Supports

U.S.ARMY

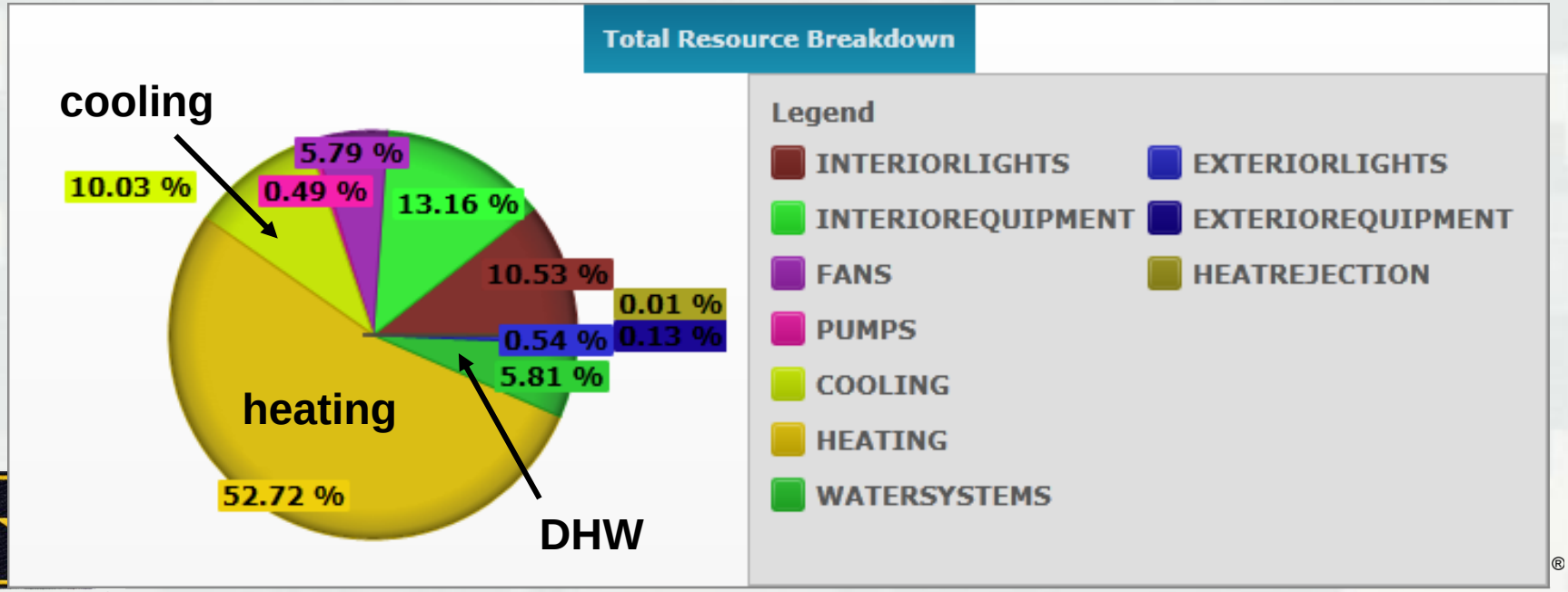
BUILDING STRONG®

Useful Definitions

- 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.
- 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 measures related to buildings, distribution systems, and generation systems. These scenarios are compared to the baseline for energy use change and to the Base Case for investment and operational costs.
- District/Cluster - a group of buildings and systems to be considered in the analysis.

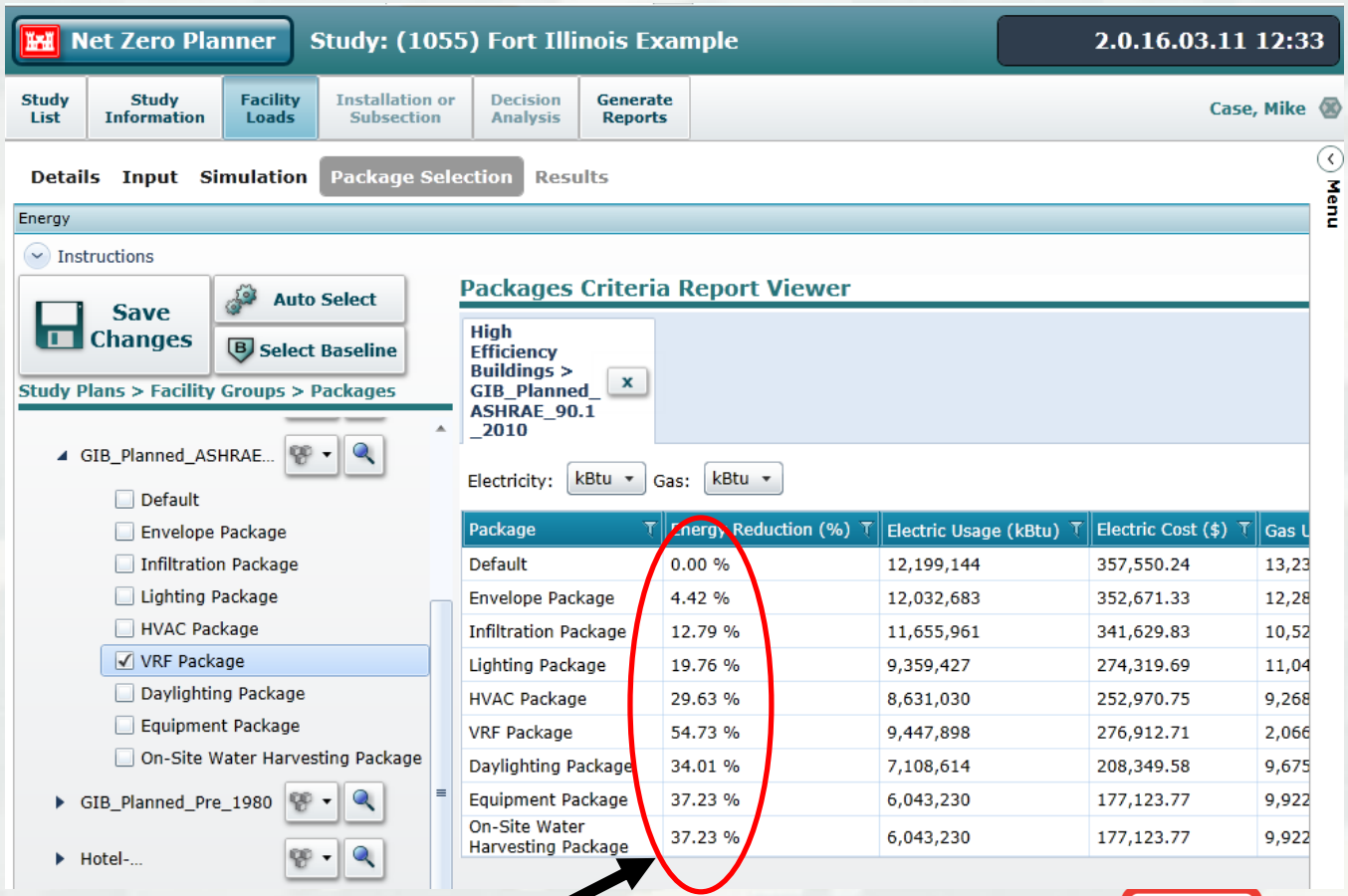
Future Base Case
End Use by Energy Use Intensity

- Examine where energy being used
- For this climate, heating loads dominate



After Simulation, User Selects Packages

- Energy savings and costs displayed
- User chooses best package for each facility type



Compare energy reduction of packages