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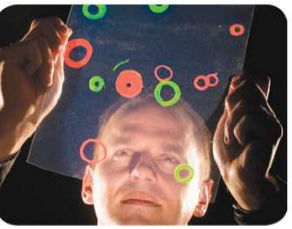

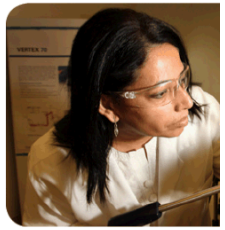

Institutional Transformation (IX)

A Software Tool to Inform Campus-Wide Energy Conservation and Sustainability Decisions

Presentation to DOE
Mar 19, 2014

Sandia National Laboratories

Exceptional service in the national interest

U.S. DEPARTMENT OF ENERGY

NNSA

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Context

- Energy Reduction Goals
  - 30% Energy Intensity (DOE)
  - 25% Energy Reduction (SNL)
  - Future Challenges
- HPSB Goals
  - Building Energy Reduction
  - ASHRAE 55/62
- Renewable Energy Goals
  - 20% by 2020

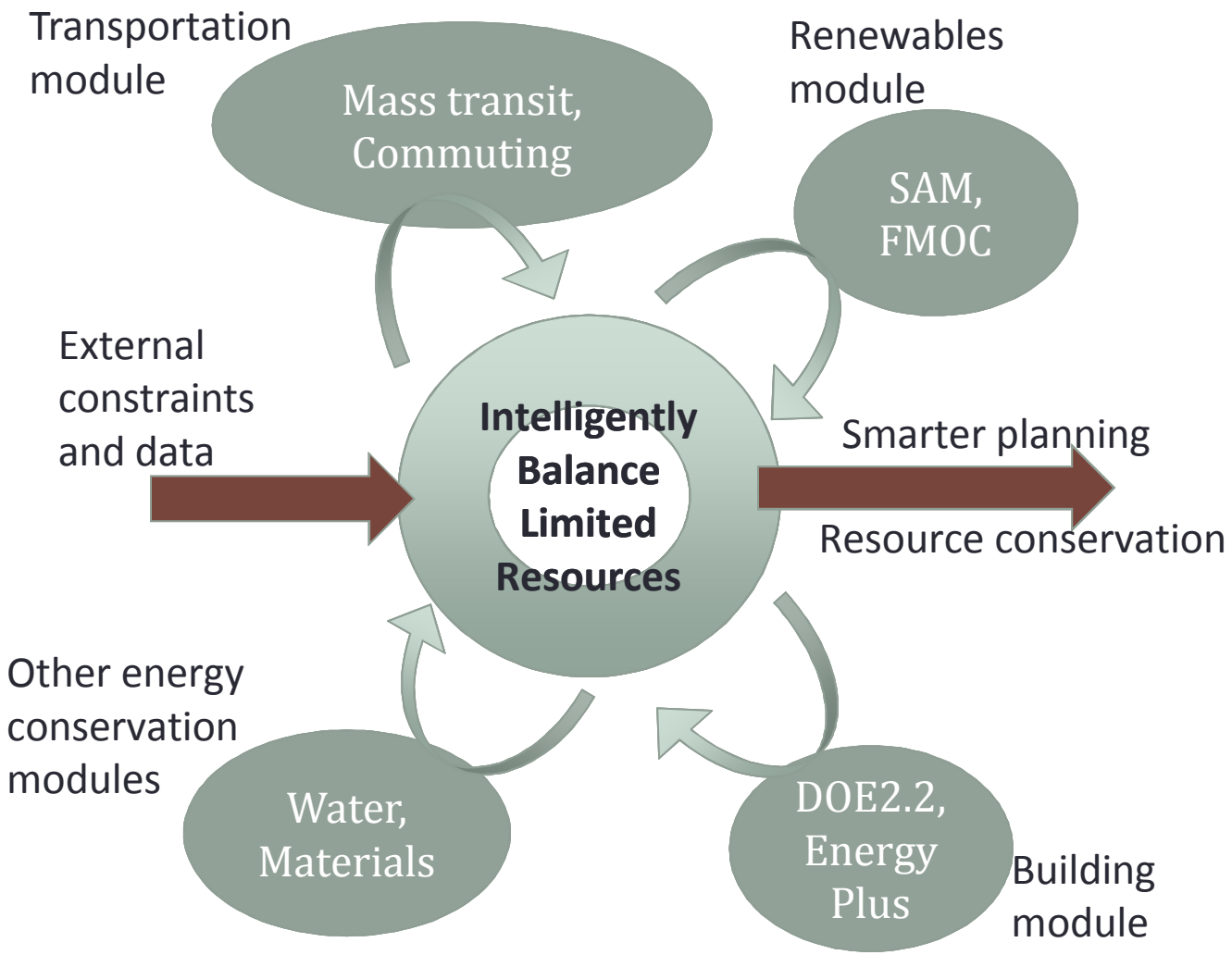
What is IX?

- A (partial) realization of a long-standing vision
- A tool to evaluate and select cost-effective energy conservation measures (ECMs), Operational Conservation Measures (OCMs) and RE options
- Integrates DOE-produced simulation software (eQUEST, PVWatts) in a Visual Basic wrapper to inform capital planning and operational decisions to increase energy efficiency/conservation
  - Mulitple ECMs
  - Multiple buildings
  - Multiple years
- Collaboratively developed by SNL facility engineers, SNL research scientists, university faculty (ASU) and a local engineering firm (Bridgers and Paxton, Inc.).
- Prototype for application to Institutional Transformation around the nation and the world

The IX Team

- **SNL Facilities**: Jack Mizner, Chris Evans, Kristina Sullivan
- **SNL Science and Technology**: Howard Passell, Daniel Villa, Len Malczynski
- **Arizona State University**: Marlin Addison
- **Bridgers and Paxton**: Matt Schaeffer, Robert Conley

IX Vision Conceptual Diagram



Outcomes:

1. Well informed integrated assessment for investment in a low energy future

2. Quality controlled foundation of data to test accuracy of previous assessments

3. Increased awareness of current energy status and feasible energy futures for planners.

Schedule

A7

ID	Task Name	2012		2013				2014			
		Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Conceptualize IX										
2	Develop RE Module										
3	Identify ECMs										
4	Develop eQuest Models										
5	Develop IX Wrapper										
6	Develop Central Plant Model										
7	Test and Refine IX										
8	Calculate ECM Costs										
9	Deploy as Decision Tool at SNl										

Slide 6

A7 This needs to be updated. I think we should get rid of the row "Calculate ECM Costs."
Author, 3/4/2014

How to Use IX

- Evaluate ECMs together or alone across building types or an entire campus (Capital Investment)
- Determine the effect on energy use of adding, retrofitting or removing buildings. (Site Planning)
- Evaluate OCMs together or alone across building types or an entire campus (Operational Efficiency; Policy Changes)
- Validate effect of implementing ECMs and OCMs (Measurement and Validation; Model Calibration)
- Evaluate renewable energy options

Today's Agenda

- IX building Module Overview - Howard Passell
- IX Cool Roof SNL Demo and Site-wide Results – Daniel Villa
- IX Temperature Setpoint SNL Site-wide Results -Jack Mizner
- Hot/Chilled Water Temp Reset – Daniel Villa
- Solar Module Demonstration – Howard Passell
- Wrap-up – Jack Mizner
- Questions and Answers

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Building Module

IX Building Module Description

- High resolution modeling and analysis of alternative energy conservation measures (ECMs) and strategies applied to one or many buildings over one or many years
- Builds upon eQUEST/DOE 2.2
- 101 eQUEST building models (9 more coming soon)
  - All Buildings on site > 10,000 ft^2 (90% of total energy consumption)
  - Building types: Office, Light Laboratory, Heavy Laboratory, Data center, Auditorium, Cafeteria, Warehouse, Education, Medical
- 24 ECMs

eQUEST Wizards

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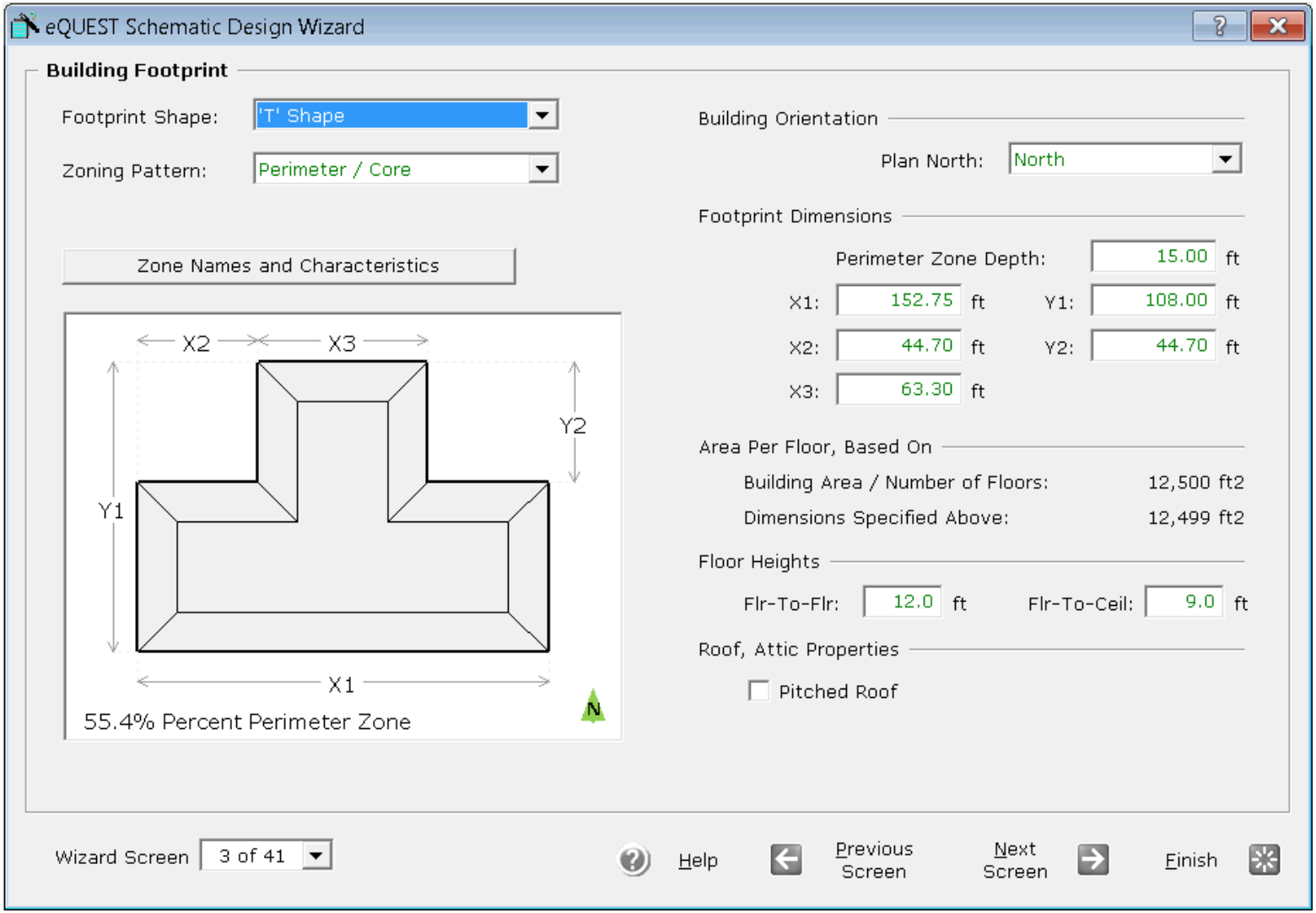

eQUEST 3-D View

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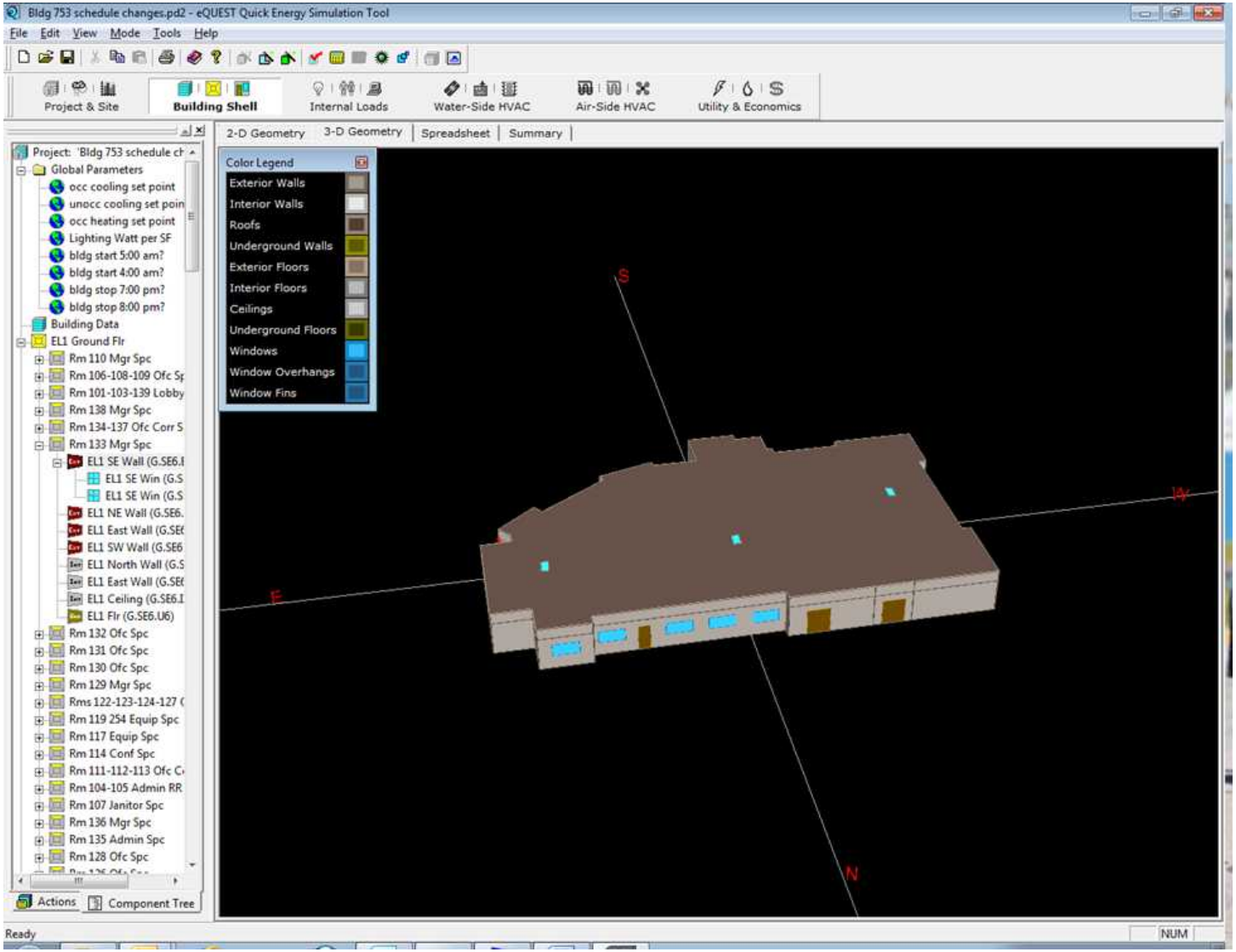
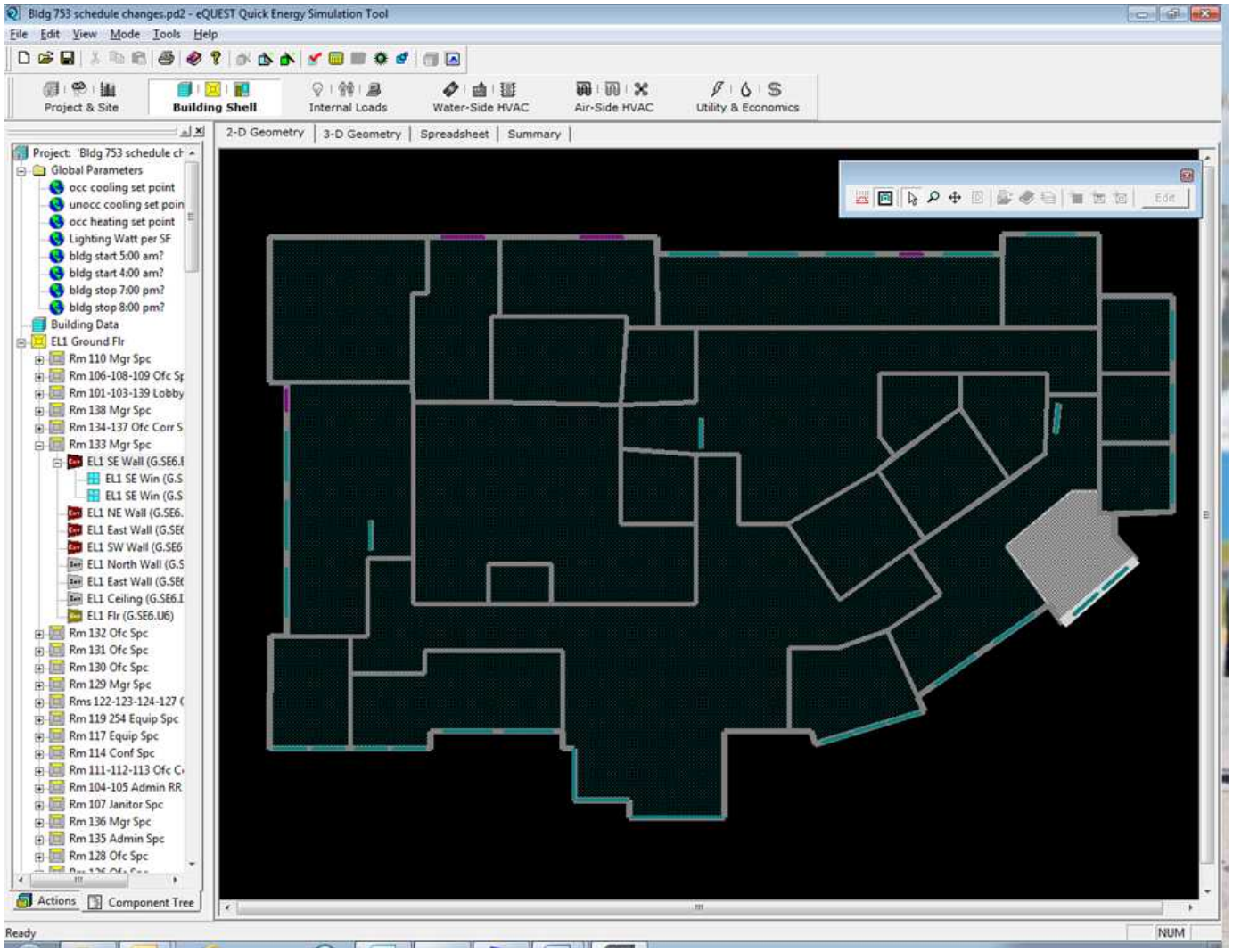
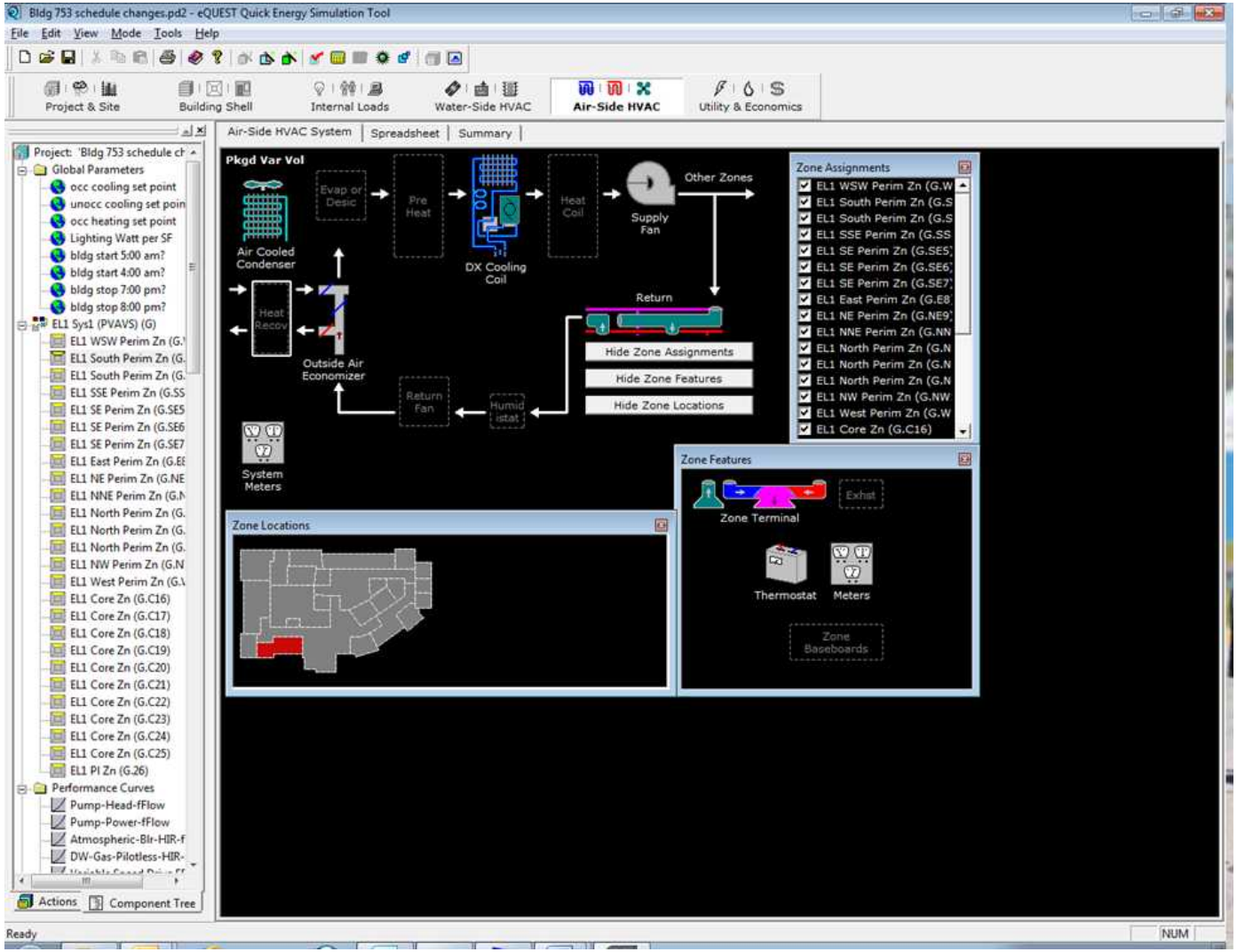


eQUEST Floor Plan and Zoning



eQUEST HVAC Management



ECMName	Category	Building Types
Air Management in IT Rooms & DC's	IT	Data Center, Light Labora
Airside Economizer Control	Retrofit HVAC	Auditorium, Cafeteria, Da
Caulk & Weatherstrip Doors & Windows	Infiltration	Auditorium, Cafeteria, Da
CHW & HW Water Temperature Reset	Heat Recovery or Load R	Auditorium, Data Center,
Cool Roof	Roof	Auditorium, Cafeteria, Da
Daylighting sensors for Top & Side lighting	Lighting	Auditorium, Cafeteria, Da
Duct Static Pressure Reset (repair & commis	HVAC Distribution Systme	Auditorium, Data Center,
Exterior Insulated Finish System (EFIS)	Wall Treatments	Auditorium, Cafeteria, Da
High Efficiency Lighting Replacments	Lighting	Auditorium, Cafeteria, Da
Install Exterior Shading Overhangs	Windows	Auditorium, Cafeteria, Da
Install Interior Shading	Windows	Auditorium, Cafeteria, Da
Insulate Roof	Roof	Auditorium, Cafeteria, Da
Lab Exhaust	Exhaust	Data Center, Heavy Labs
Limit Personal Space Heater Use	Plug Loads	Auditorium, Cafeteria, Da
New Window or Glass Properties	Windows	Auditorium, Cafeteria, Da
Night Cooling	Energy-Efficient Cooling S	Auditorium, Cafeteria, Da
Plate Heat Exchangers Water Side Economiz	Heat Recovery or Load R	Auditorium, Data Center,
Reduce Fan Operation Hours	Building Automation syste	Auditorium, Cafeteria, Da
Reduce Illumination Levels	Lighting	Auditorium, Cafeteria, Da
Reduce Plug Loads	Plug Loads	Auditorium, Cafeteria, Da
Seal Vertical Shafts & Stairways	Envelope Sealing	Data Center, Heavy Labs,
Supply air temperature reset	Retrofit HVAC	Data Center, Education, H
T-Stat management (Temp setback & occ se	Building Automation syste	Auditorium, Cafeteria, Da
VAV Box Occupancy Sensors	Retrofit HVAC	Auditorium, Cafeteria, Da

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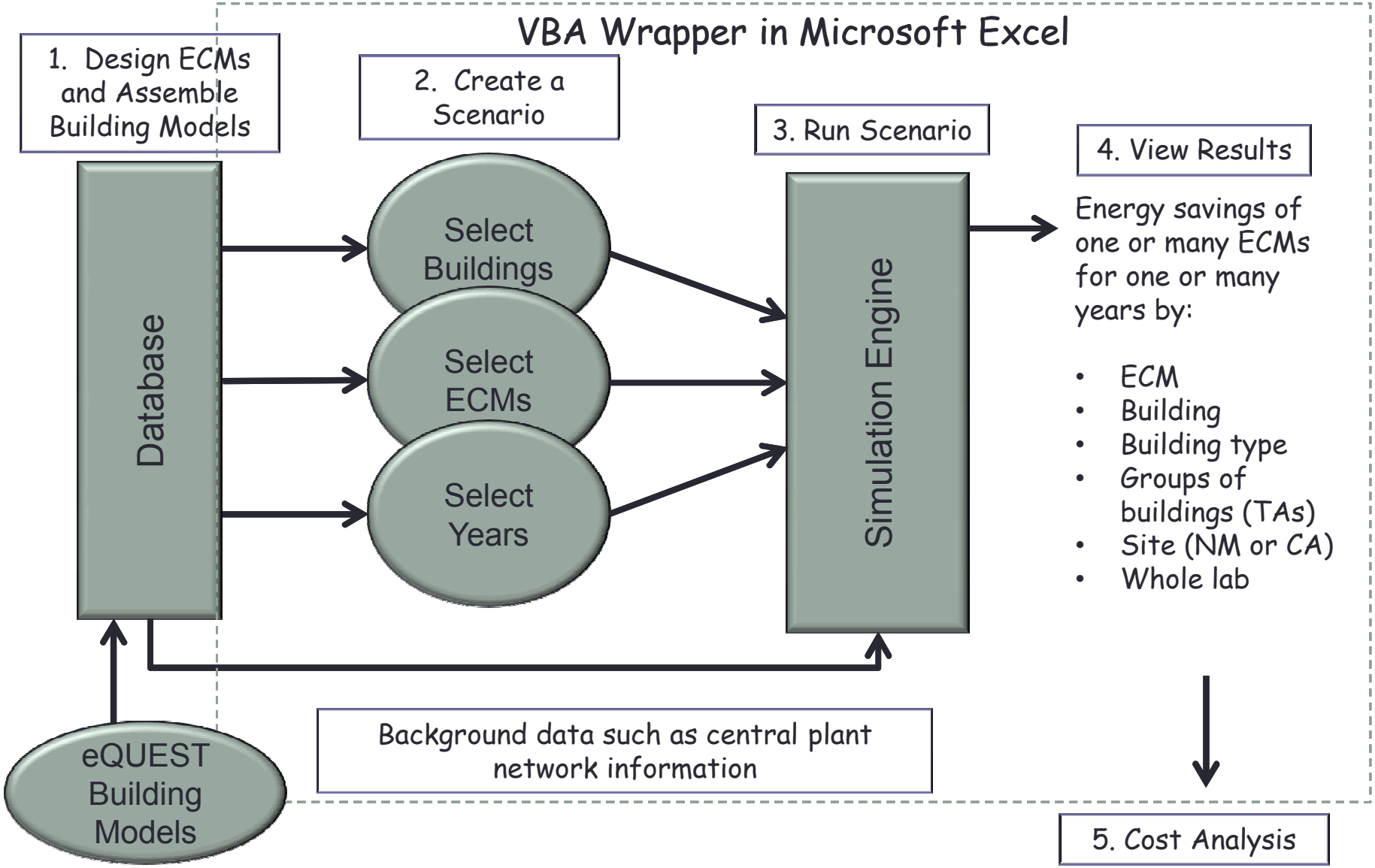
Current IX ECMs

Building Module Software Architecture



Building Module FY 14 Goals

- IX Version 3.0 scheduled to be completed **September 2014**.
  - Calibration/validation
  - Capability to integrate all modules (solar, building, transportation, etc.)
  - Improved data management
  - Better user interface
  - Central utility buildings (CUBs)
  - Building creation and destruction
  - Variable future weather

Future IX Goals

- In addition to buildings and renewable energy, the future IX will analyze . . .
  - energy storage options
  - other renewable energy sources
  - transportation alternatives
  - material flows
  - water conservation
  - life cycle cost estimates/ROI
- Useful for national labs, military bases, city/state/federal government complexes, industrial complexes . . .
- Lays a groundwork for ‘smart buildings’

IX Building Module 2.16 Live Demo of Cool Roof ECM on SNL NM Buildings 860 and 802

Scenario

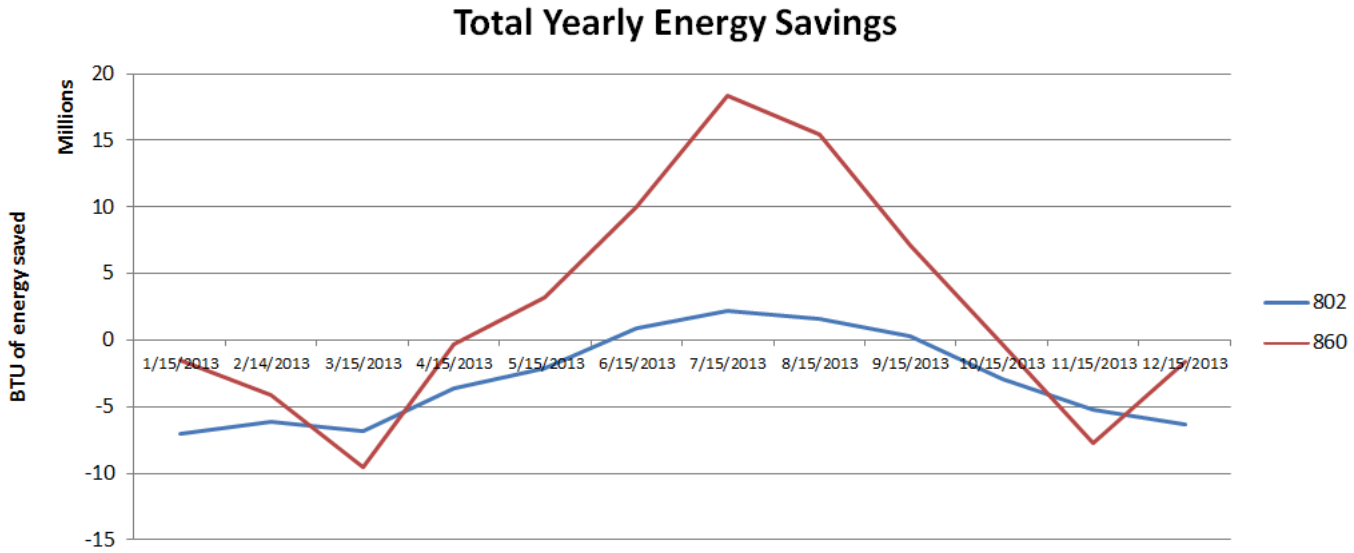
- Cool Roof ECM Description: Add roofing material which reflects solar radiation away from a building
  - Reduces cooling demand in summer, but increases heating demand in winter
  - All buildings are not the same . . .
- Simulate results of applying cool roofs to two buildings at SNL, NM, Bldgs. 802 and 860
  - One ECM
  - One Year

Demo Conclusion

- Cool roofs do not always save energy for the SNL/NM site

	802	860	Grand Total
Sum of Energy Savings (BTU)	-3.521E+07	2.905E+07	-6.160E+06

Energy losses



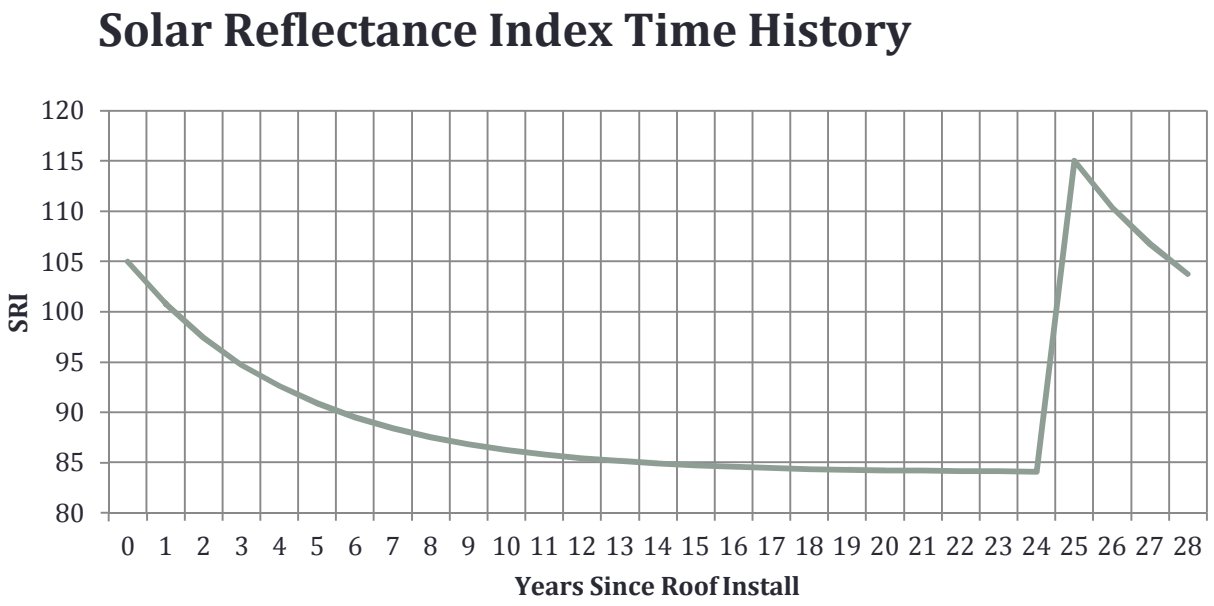
IX Cool Roof
SNL Site-Wide Results

Introduction

- **Purpose:** Simplified demonstration of IX Building Module 2.16 for an entire site
- **Planning Objectives:**
  - Apply a new cool roof to buildings in the order which saves the maximum amount of energy over time with a limited budget
  - Simultaneously bring any non-compliant insulation of roofs up to ASHRAE 90.1 2010
  - Avoid applying cool roofs and insulation to buildings which do not save energy
- **Hypothesis:** IX produces greater energy savings than a random application of the cool roof and insulation ECMs across the site

Physical Inputs/Assumptions

- High-end cool roof with solar reflectance index (SRI) of 105 at start year which decays by 20% per year to a threshold value of 84
- Twenty-five year life of roofs with 115 SRI roof assuming better technology
- Insulation raised to R38 over 90% of the roof of every building

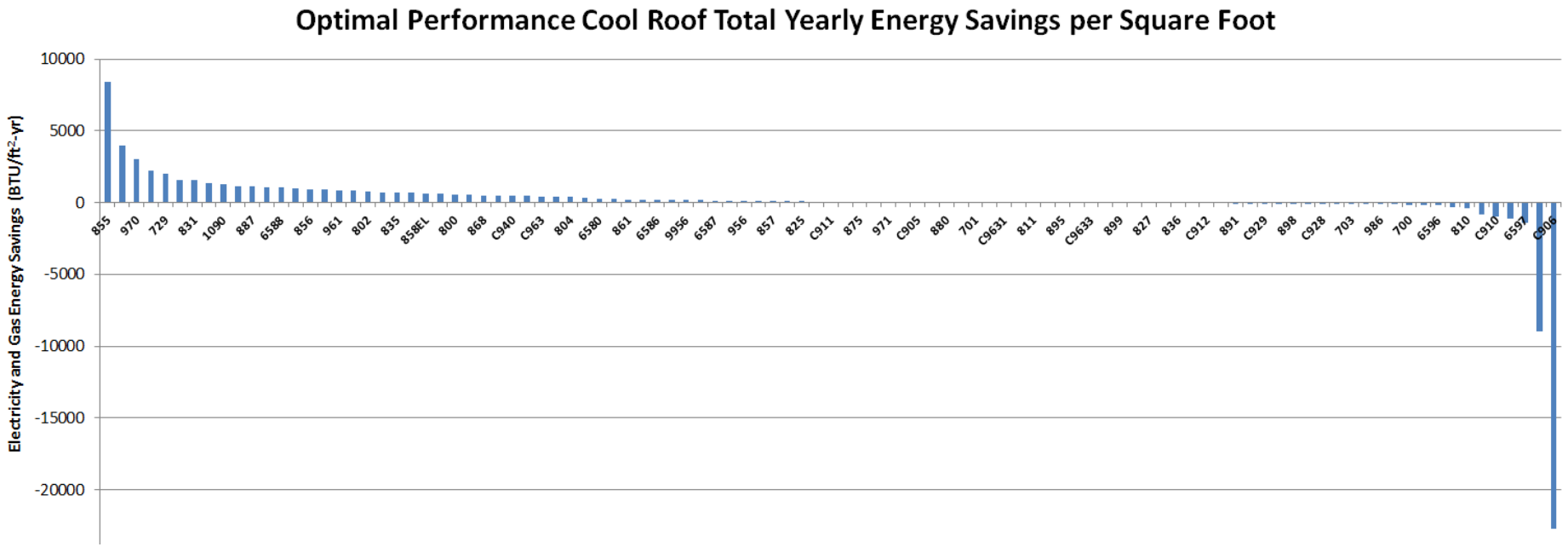


Economic Inputs/Assumptions

- $1M per year from 2012 to 2040
- Constant installation rate of $3 per ft^2
- Standard maintenance to keep the roof surface clean is assumed
- Assume all economic effects stay constant over time

Establish Optimal Simulation Order

- Apply insulation and cool roof to all 101 buildings and run 1 year
- Sort the total energy savings for all buildings from highest to lowest



Scenario Data Input

- Bldgs. in blue require no cool roof/insulation
- Bldgs. in pink are treated in order of highest to lowest energy savings until the annual $1M budget is met
- Bldgs. in white show 20% annual decay to SRI of 84
- Bldgs. are treated again after 25 years.

Blue means SRI = 60

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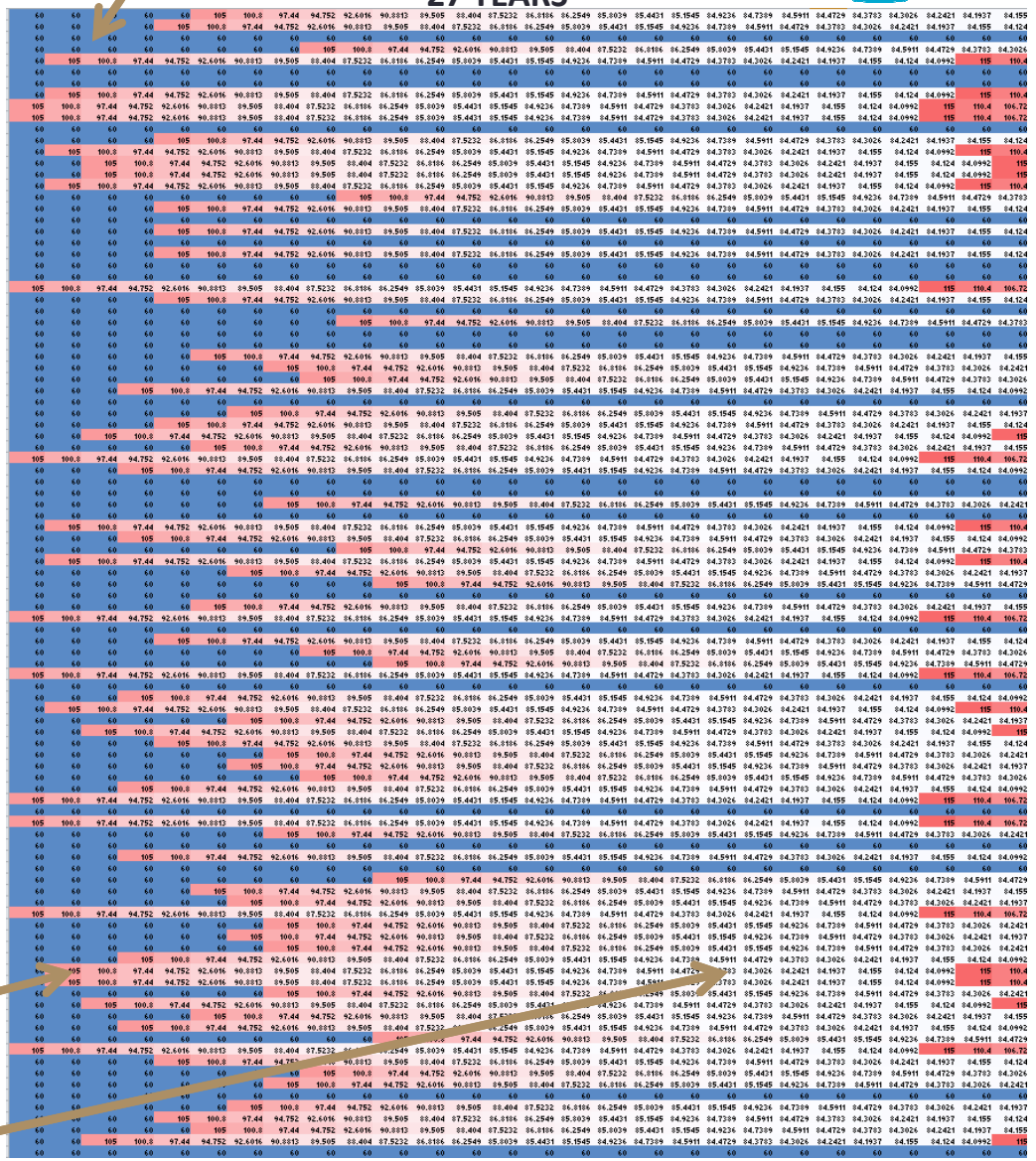
27 YEARS

101 BUILDINGS

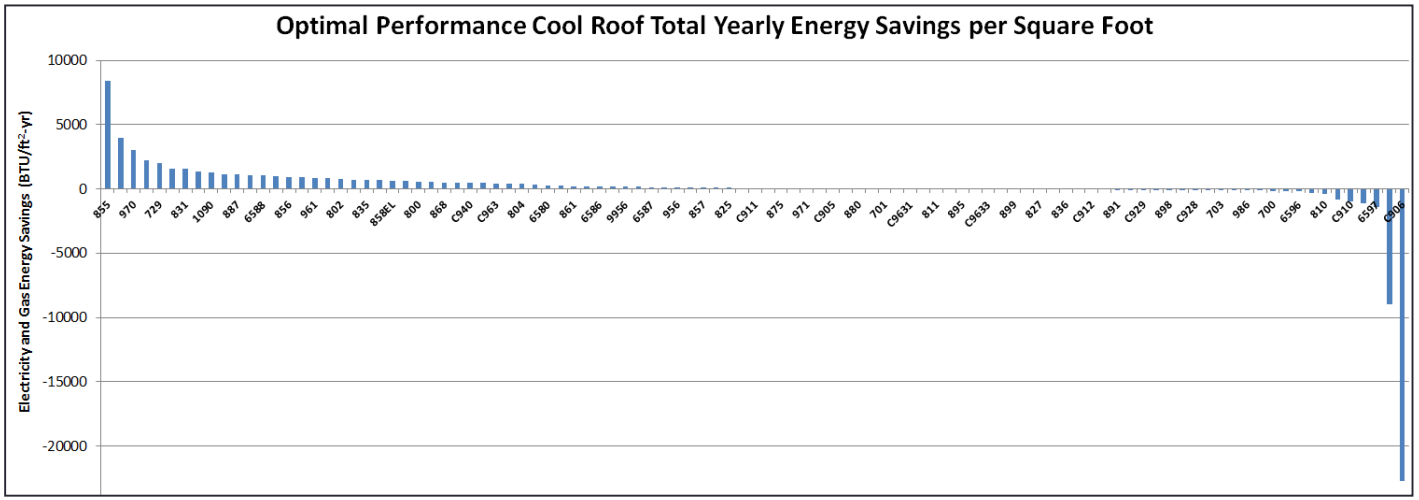
Red means SRI ~ 105-115

White means SRI ~ 84



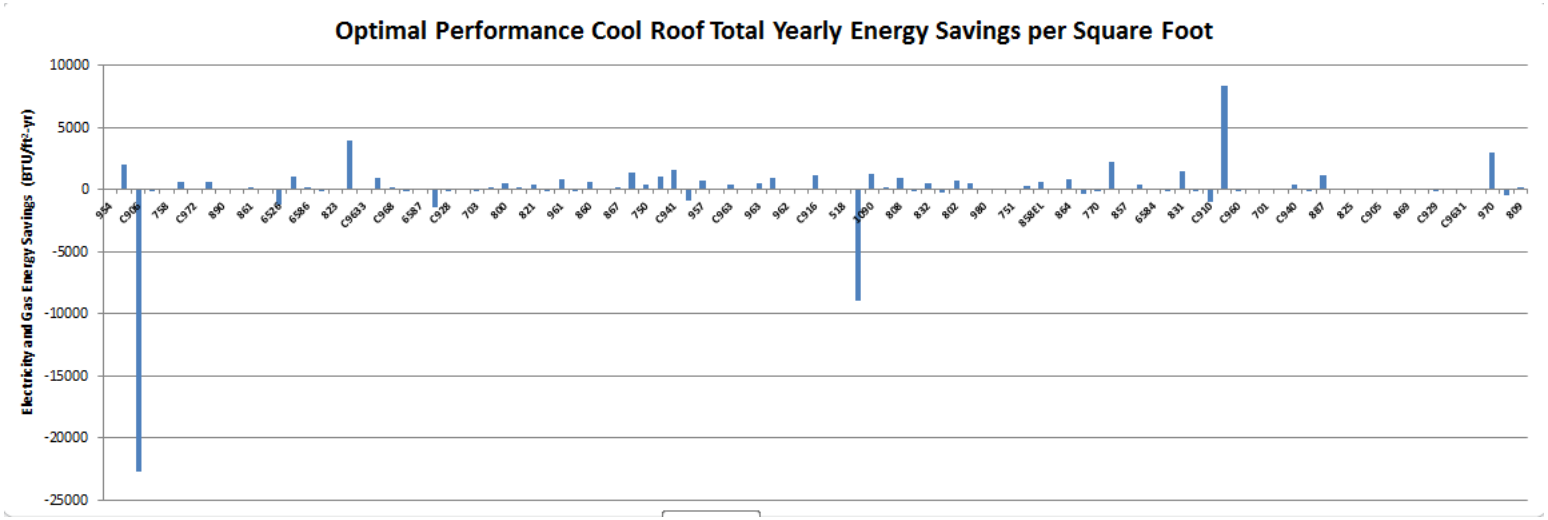
Cases to Test Hypothesis

- Randomize order of buildings from this graph

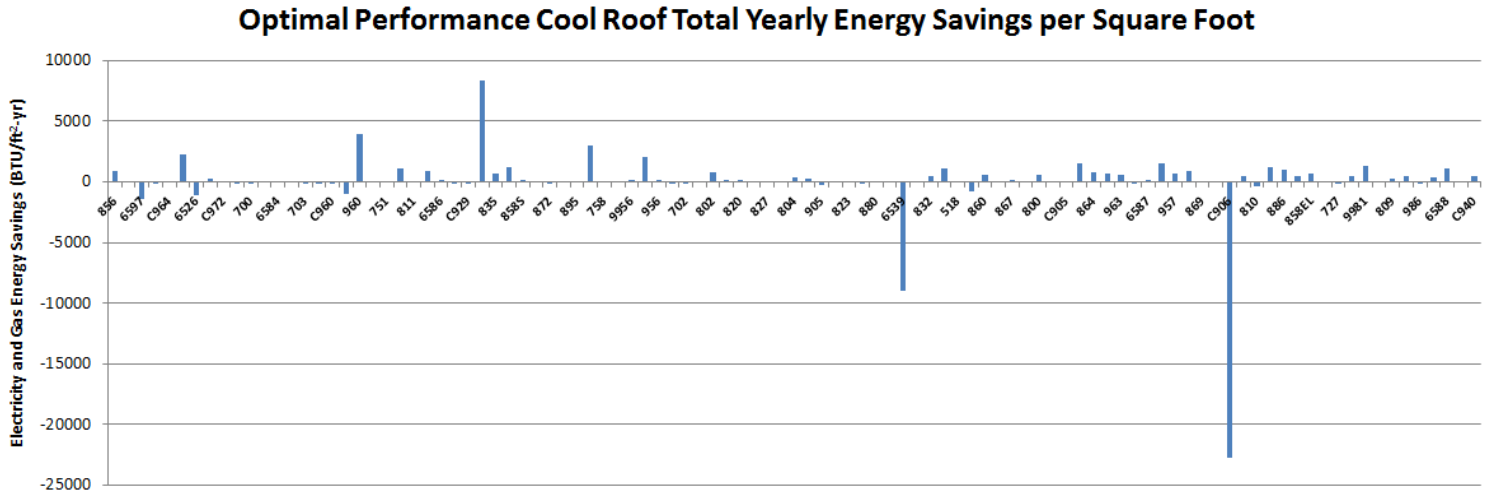


- Apply cool roof and insulation with the same 1M budget constraint to the randomized order of buildings
- Find worst case by sorting buildings from least to greatest energy savings
- Evaluate energy savings

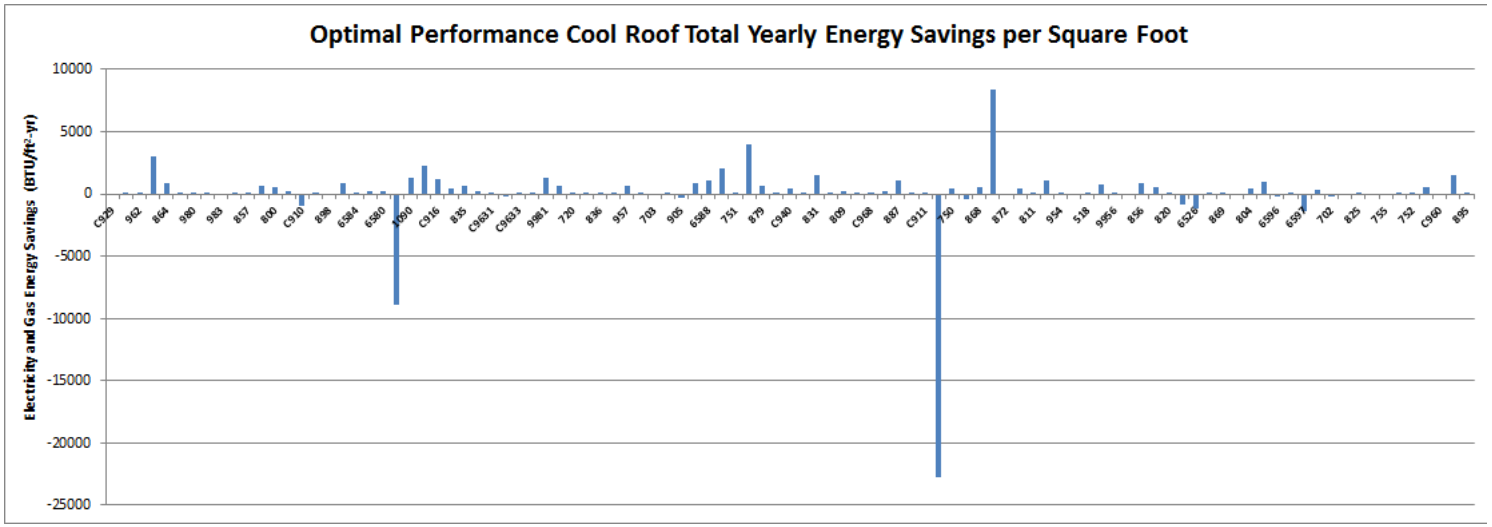
Random Case 1



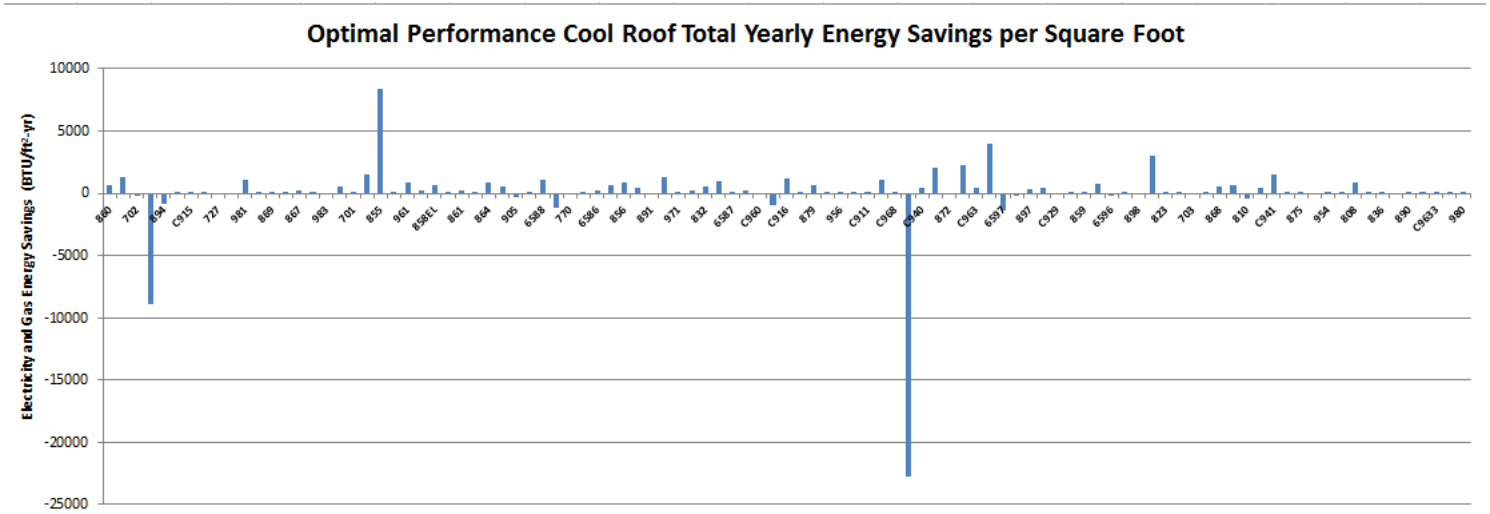
Random Case 2



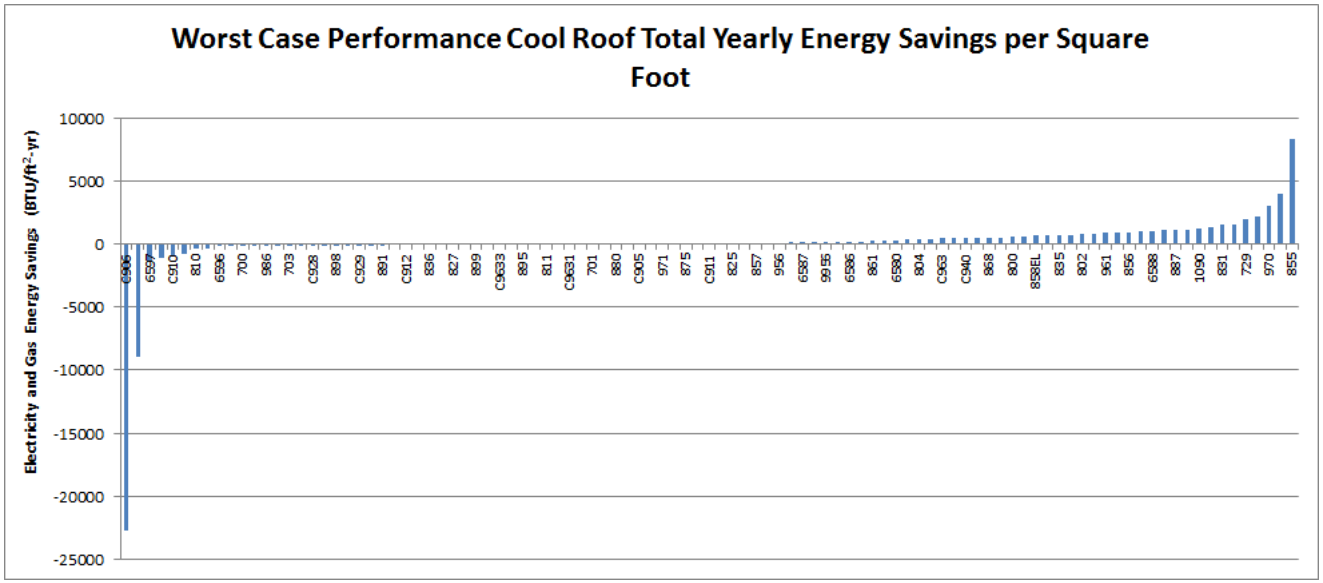
Random Case 3



Random Case 4



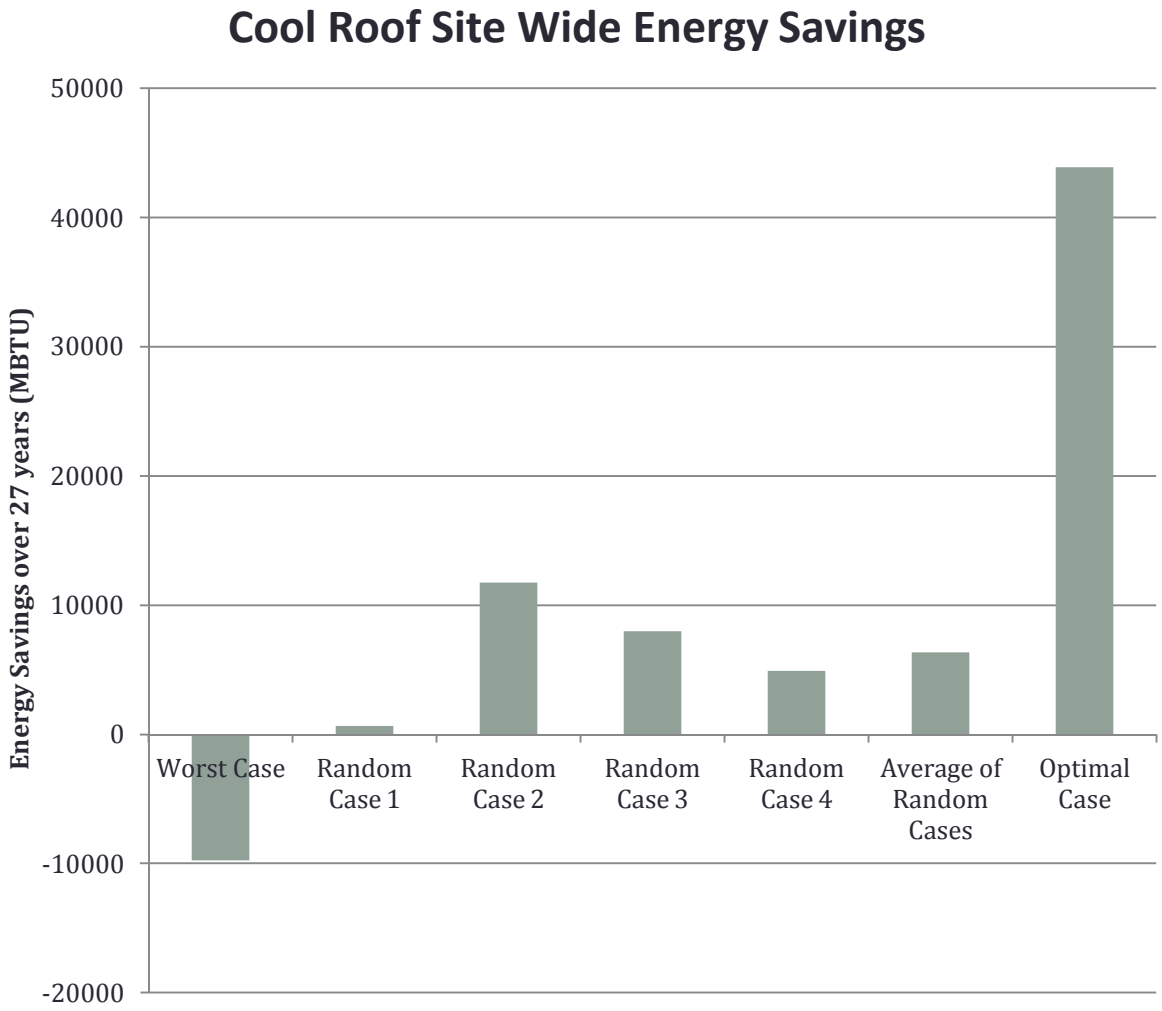
Worst Case Scenario



Results

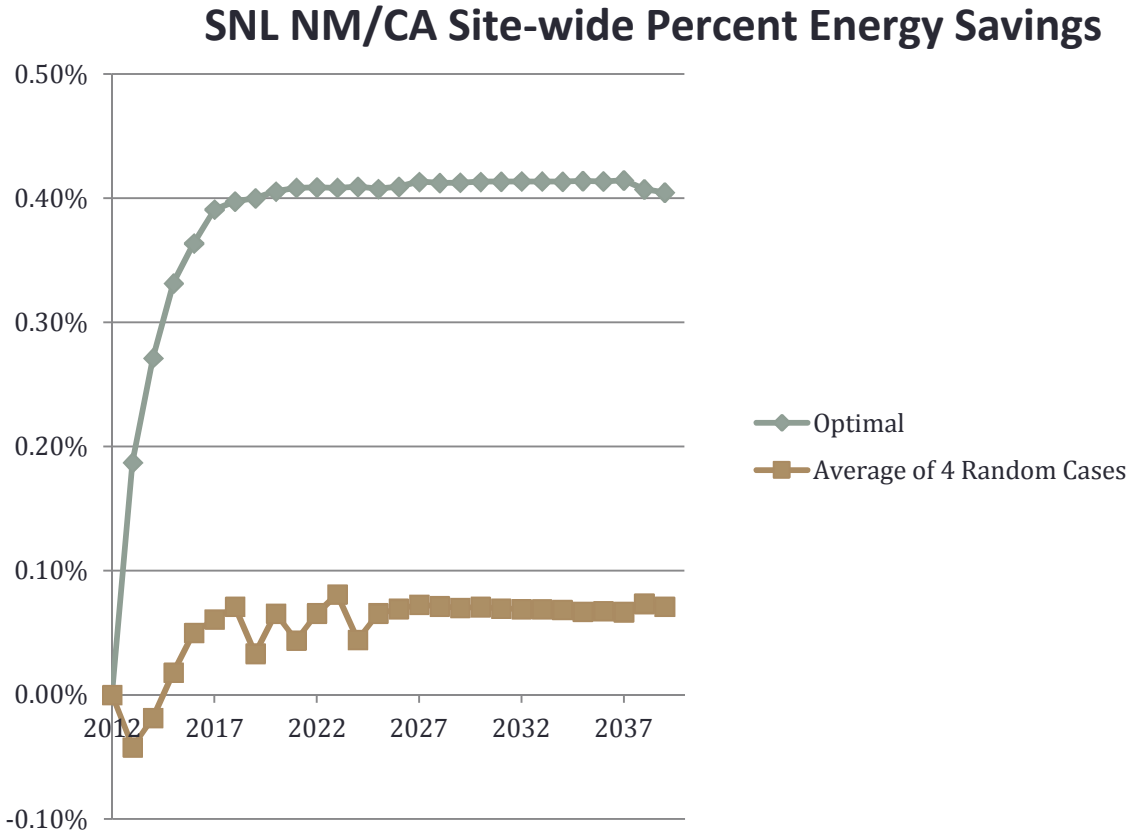
- IX optimal case performed 4x better
- Hypothesis that IX makes a significant difference is strongly supported

Over 14,000 DOE2.2 building simulation runs were required for these scenarios



Percentage Savings

- Site-wide energy savings for this ECM is only 0.4%
- If cool roof and insulation costs are high, other ECMs may be more desirable



Conclusion

- Using IX can make a big difference in site-wide energy savings
- The cool roof/roof insulation scenario has significant energy savings for selected buildings but does not have a large effect site-wide
- Further analysis of competing technologies, economies of scale, and detailed life cycle cost analysis will make IX's assessments even more powerful

Temp Set Point

Problem Statement

- How do we balance employee comfort, mission productivity, and operational efficiency with energy conservation?
  - Provide cover for FMOC Operations
  - Base the solution on established standard (ANSI/ASHRAE 55)
    - 80% Occupant Satisfaction
  - Base the solution on corporate governance
    - 25% Reduction goal
  - Minimize the use of personal comfort devices
  - Engage the workforce

Potential Energy Reductions – B 753

		Annual Total Site Energy		
		Elect kWh	Nat Gas Therms	Total Mbtu
Incremental SAVINGS *(percentage savings shown in parentheses, negative entries indicate increased use or cost)*				
1	0+Cooling 77 to 78	383 (0%)	6 (1%)	1.9 (0.4%)
2	0+Cooling 77 to 79	683 (1%)	9 (1%)	3.2 (0.7%)
3	**0+Cooling 77 to 80**	930 (1%)	13 (1%)	**4.5 (0.9%)**
4	0+Cooling 77 to 81	1,085 (1%)	15 (1%)	5.2 (1.1%)
5	0+Cooling 77 to 82	1,156 (1%)	18 (2%)	5.7 (1.2%)
6	**0+Heating 70 to 69**	32 (0%)	96 (8%)	**9.7 (2%)**
7	0+Heating 70 to 68	63 (0%)	177 (15%)	17.9 (3.7%)
8	0+Heating 70 to 67	85 (0%)	252 (22%)	25.5 (5.3%)
9	0+Heating 70 to 66	103 (0%)	326 (28%)	33.0 (6.9%)
10	0+Fans On 7a - 6p (was 6a - 6p)	595 (1%)	53 (5%)	7.3 (1.5%)
11	0+Fans On 7a - 5p (was 6a - 6p)	746 (1%)	75 (6%)	10.0 (2.1%)
12	**0+Clg 77 to 80, Htg 70 to 69, Fans 7a-5p**	1,981 (2%)	175 (15%)	**24.3 (5.1%)**

All Office Buildings: 188,358 MBtu; 5% Reduction = 9,417MBtu
Total Site Energy Reduction ~ 1%

Potential Energy Reductions – B 753

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Baseline:
TEMP: 70 - 77^{o} F
FANS: 6 am-6 pm

Operational ECM	Elect (kWh)	Nat Gas Therms	Total MBTUs
Raise T Set, 77 to 78	383 (0%)	6 (1%)	1.9 (0.4%)
Raise T Set 77 to 80	**930 (1%)**	**13 (1%)**	**4.5 (0.9%)**
Raise T Set, 77 to 82	1,156 (1%)	18 (2%)	5.7 (1.2%)
Lower T Set, 70 to 69	**32 (0%)**	**96 (8%)**	**9.7 (2%)**
Lower T Set, 70 to 68	63 (0%)	177 (15%)	17.9 (3.7%)
Lower T Set 70 to 66	103 (0%)	326 (28%)	33.0 (6.9%)
Fans on 7am – 6pm	595 (1%)	53 (6%)	7.3 (1.5%)
Fans on 7am – 5pm	**746 (1%)**	**75 (6%)**	**10.0 (2.1%)**
T Set 69 – 70; Fans 7am – 5pm	1,981 (2%)	175 (15%)	24.3 (5.1%)

All Office Buildings: 188,358 MBTU; 5% Reduction = 9,417MBTU
Total Site Energy Reduction ~ 1%

Path Forward

- Use the results to make a fact-based decision
  - White Paper with recommendations
  - Present the results clearly and concisely to upper management
- Translate these results into a corporate policy

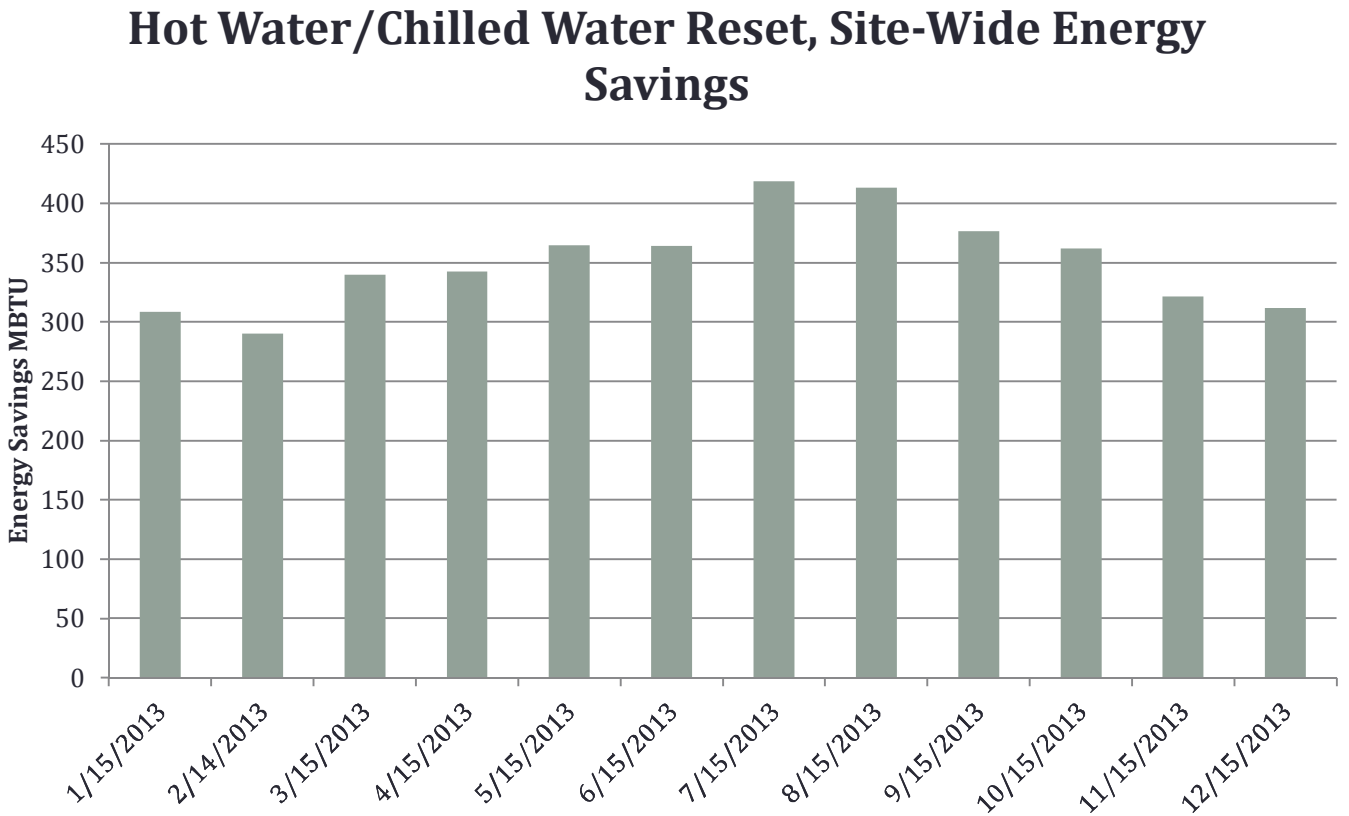
Hot Water/Chilled Water Reset

Hot Water/Chilled Water Reset

- **ECM Description:** Add controls which allow increase in chilled water temperature when cooling demand is low, and which allow decrease in hot water temperature whenever heating demands are low
- **Purpose:** Quantify site-wide potential for energy savings due to application of hot/chilled water reset ECM
- **Procedure:** Run entire site with and without hot/chilled water reset

Results

- Site-wide, 1% savings are predicted by IX



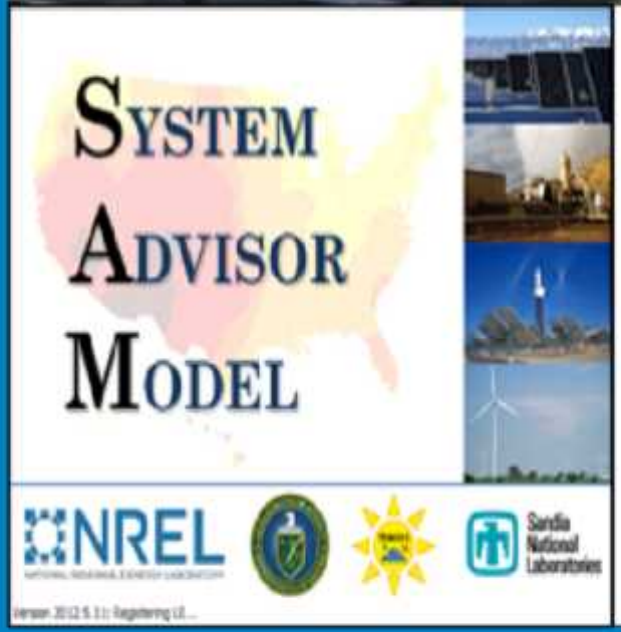
Conclusion

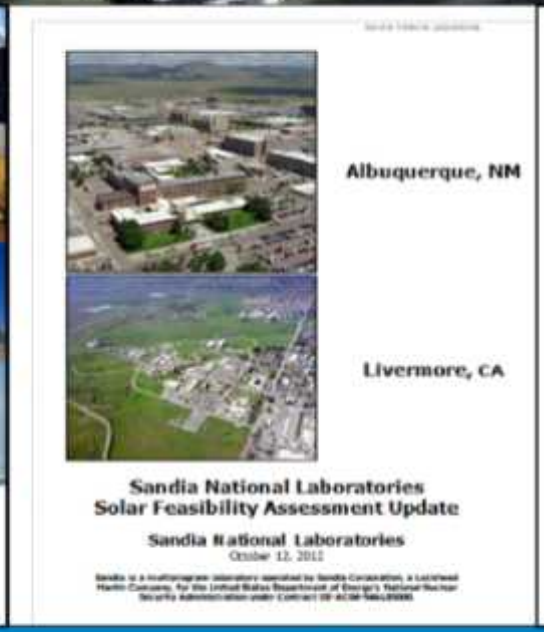
- Hot water/chilled water reset ECM has a higher potential than cool roof/insulate roof ECM
- The largest scale IX scenario is to evaluate the sensitivity of all relevant ECMs to all buildings and seek for an optimal future scenario with a thorough cost analysis included

Solar Module

Home
User Input
Results
Background
Site Map
Model

IX Solar Installations
Draft Model





Background

Objective: To assess long term cost and generating potential of various solar installation configurations at SNL

- Evaluated 18 locations at SNL/NM which have greatest potential for immediate implementation
- Ground mount PV, Roof mount PV, concentrating PV, and concentrating solar thermal (CST).
- National Renewable Energy Laboratory's (NREL) System/Solar Advisor Model (SAM) was used to generate capital and O&M costs.
- State and federal tax incentives and rebates are included

Table 1. Site Investigation for Placing PV on the SNL/NM Site

	Sites / Description	Acreage	Technology	MW Capacity	Production MWh/yr
1	KAFB land east of PSEL Undeveloped land north of G Ave.	7.8	Ground-mounted PV	0.98	2187.4
2	South of G Ave. Undeveloped dirt strip of land	1.0	Ground-mounted PV	0.13	280.4
3	Building 887 existing parking lot North of H Ave.	9.0	PV on parking shade structure	1.13	2523.9
4	Building 832 parking lot Existing parking lot and buildings to be removed	4.5	PV on parking shade structure	0.56	1261.9
5	Building 878 roof South section of existing roof	0.9	Roof-mounted PV/PV membrane	0.11	252.4
6	Building 880 roof Center section of existing roof	1.1	Membrane or roof-mounted PV	0.14	308.5
7	South of Building 821 Existing parking lot	0.7	PV on parking shade structure	0.09	196.3
8	SW Corner Building 825 parking lot Existing parking lot	2.5	PV on parking shade structure	0.31	701.1
9	Building 956 running track Center of existing running track	1.7	Ground-mounted PV	0.21	467.7
10	East end of Area II Undeveloped land on top of escarpment	15.0	Ground-mounted PV	1.88	4206.4
11	South end of Area II Undeveloped land north of R Ave.	12.0	Ground-mounted PV	1.51	3365.2
12	North of Substation 42 Undeveloped land south of R Ave. and east of 9th St.	1.8	Ground-mounted PV	0.23	504.8
13	Area IV parking lot Existing parking lot south of S Ave. and east of 9th St.	6.5	PV on parking shade structure	0.81	1822.8
14	DETL site Paved land east of MO 290 and south of F Ave.	0.4	Ground-mounted PV	0.05	112.2
15	PSEL site Undeveloped land at north edge of PSEL site	0.5	Ground-mounted PV	0.06	140.2
16	Building 956 roof Center section of existing roof	0.4	Roof-mounted PV/PV membrane	0.05	112.2
17	Building 970 roof East section of existing roof	0.5	Roof-mounted PV/PV membrane	0.06	140.2
18	Building 897 roof South section of existing roof	0.2	Roof-mounted PV/PV membrane	0.03	56.1
	Totals	**66.9**		**8.34**	**18639.7**

Modified from Hertweck (2010)

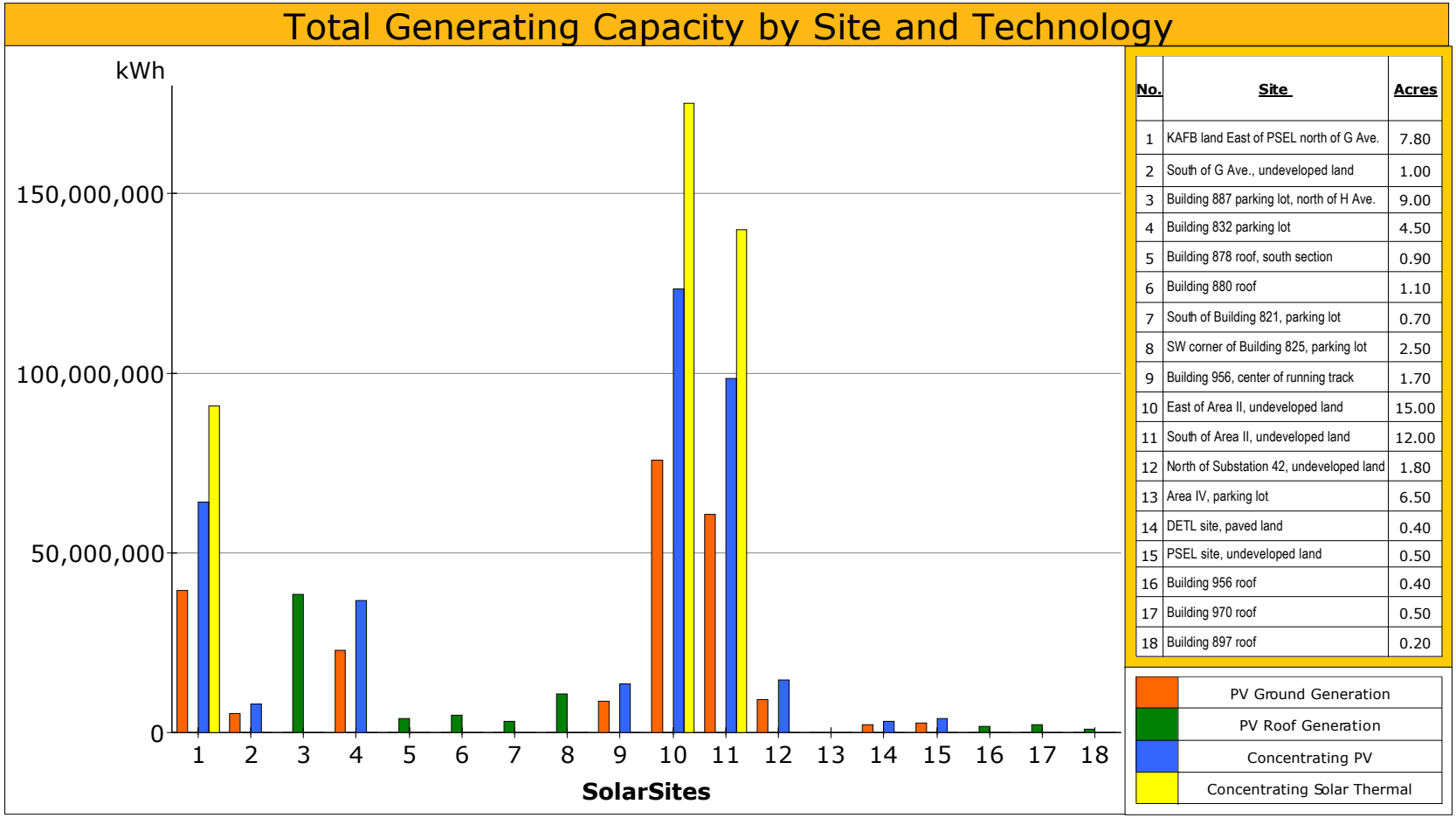
Default Financial Assumptions

- O&M and capital costs derived from SAM
- Derating of generation capacity percentage = 0.5% per yr
- Reduction in solar installation costs = 3% per yr
- Increase in electricity cost = 1.5% per yr
- Federal Rebate = 30% of capital costs through 2016
- Renewable Energy Credit = $0.04 per kWh
- NM Renewable Energy Production Tax Credit = $0.027 per kWh
- NM Advanced Energy Credit = 6% on projects greater than 1MW
- Inflation Rate = 3.0
- Sandia overhead factor = 2
- Net Present Value (NPV)

$$\sum_{t=0}^{t}(cash\ inflow\ -\ cash\ outflow)\text{^}\left\{\frac{(1+inflation\ rate)}{(1+nominal\ discount\ rate)}\right\}\text{^}t$$

Go to model

Scoping-level analysis: all technologies installed to maximum capacity at all appropriate sites in 2014 – **total generating capacity**



No.	Site	Acres
1	KAFB land East of PSEL north of G Ave.	7.80
2	South of G Ave., undeveloped land	1.00
3	Building 887 parking lot, north of H Ave.	9.00
4	Building 832 parking lot	4.50
5	Building 878 roof, south section	0.90
6	Building 880 roof	1.10
7	South of Building 821, parking lot	0.70
8	SW corner of Building 825, parking lot	2.50
9	Building 956, center of running track	1.70
10	East of Area II, undeveloped land	15.00
11	South of Area II, undeveloped land	12.00
12	North of Substation 42, undeveloped land	1.80
13	Area IV, parking lot	6.50
14	DETL site, paved land	0.40
15	PSEL site, undeveloped land	0.50
16	Building 956 roof	0.40
17	Building 970 roof	0.50
18	Building 897 roof	0.20

Evaluation of sites with highest generating capacity

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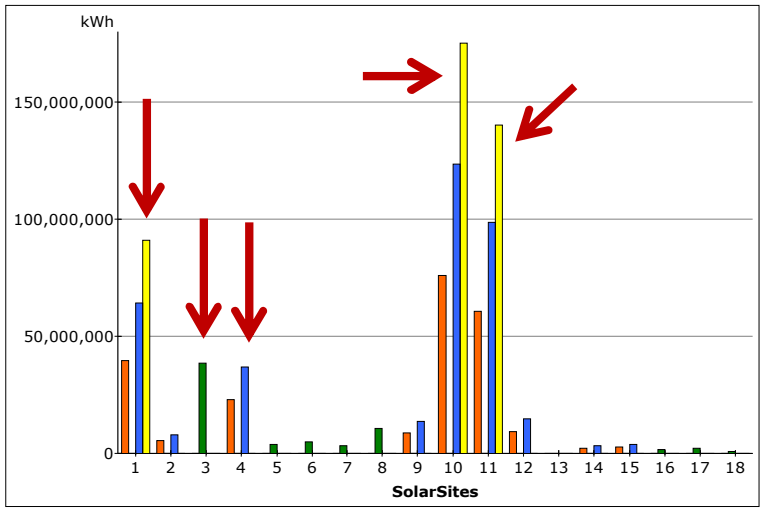
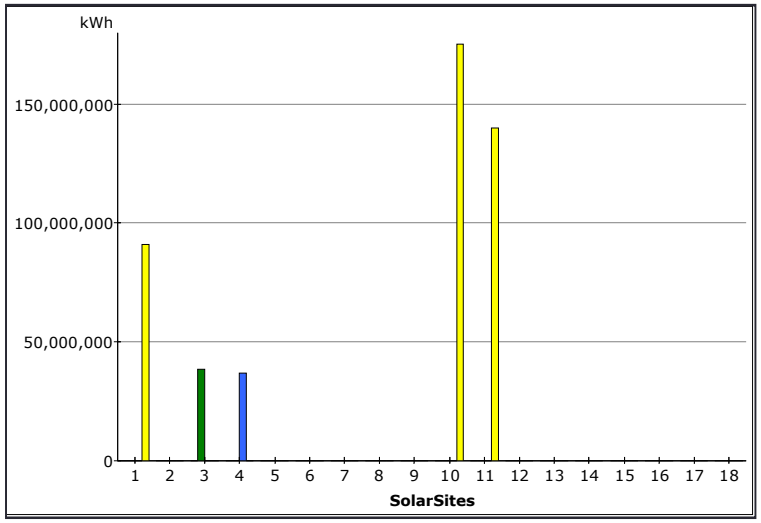
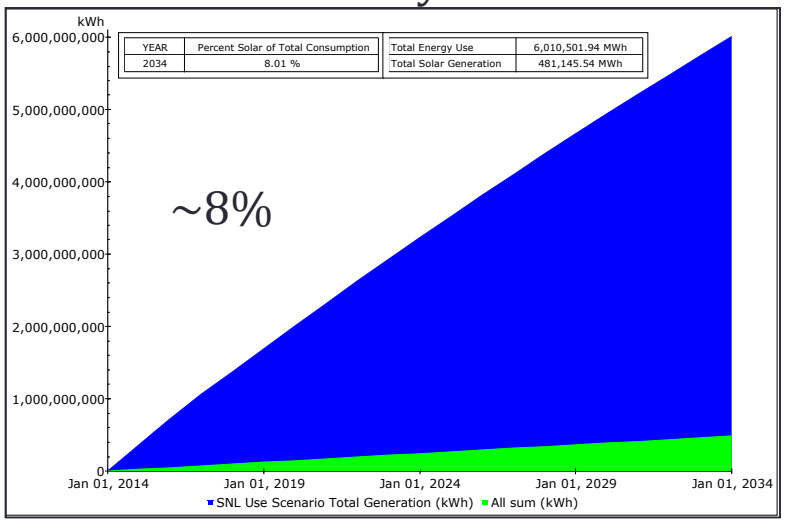
Total Generating Capacity



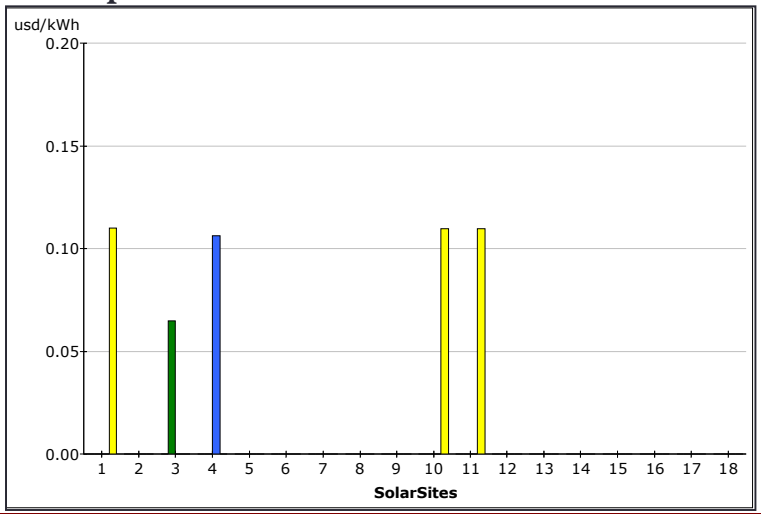
Total Generating Capacity



Percent use met by solar

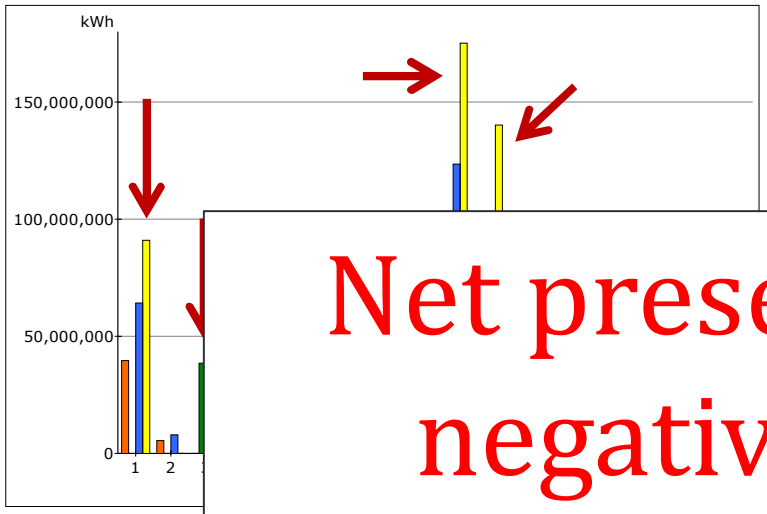


Cost per kWh

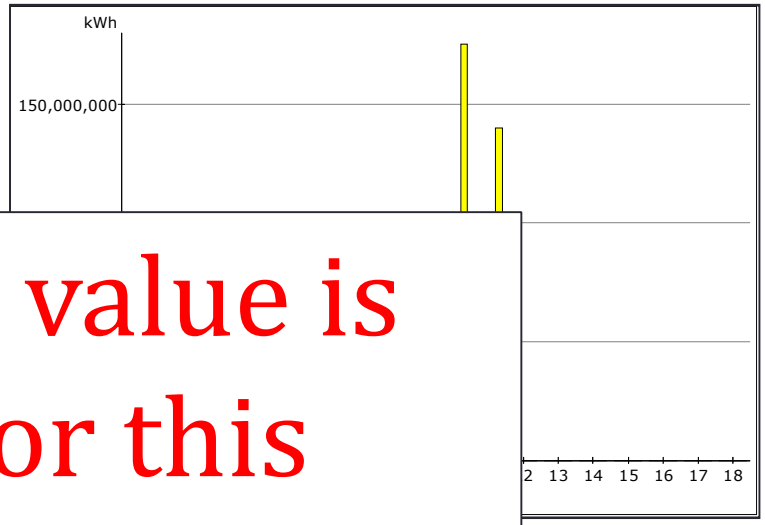


Evaluation of sites with highest generating capacity

Total Generating Capacity

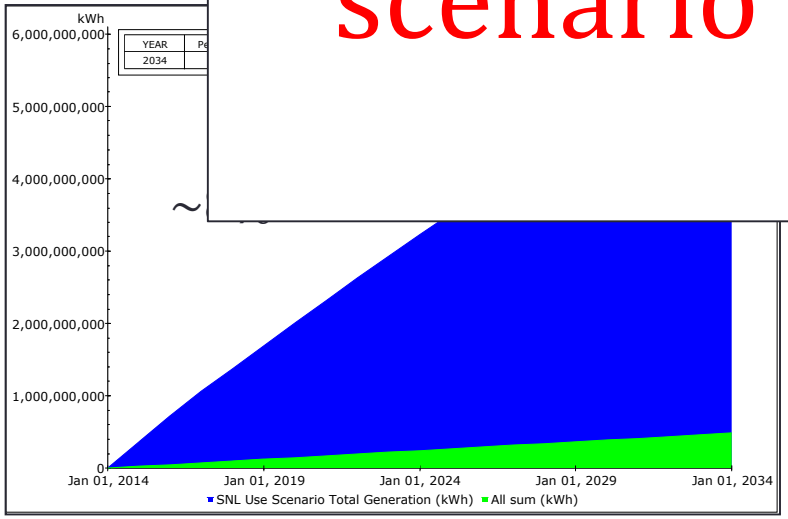


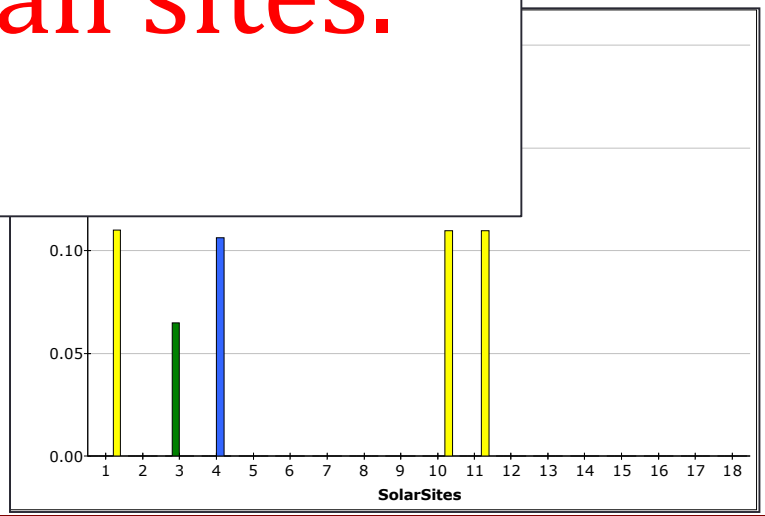
Total Generating Capacity



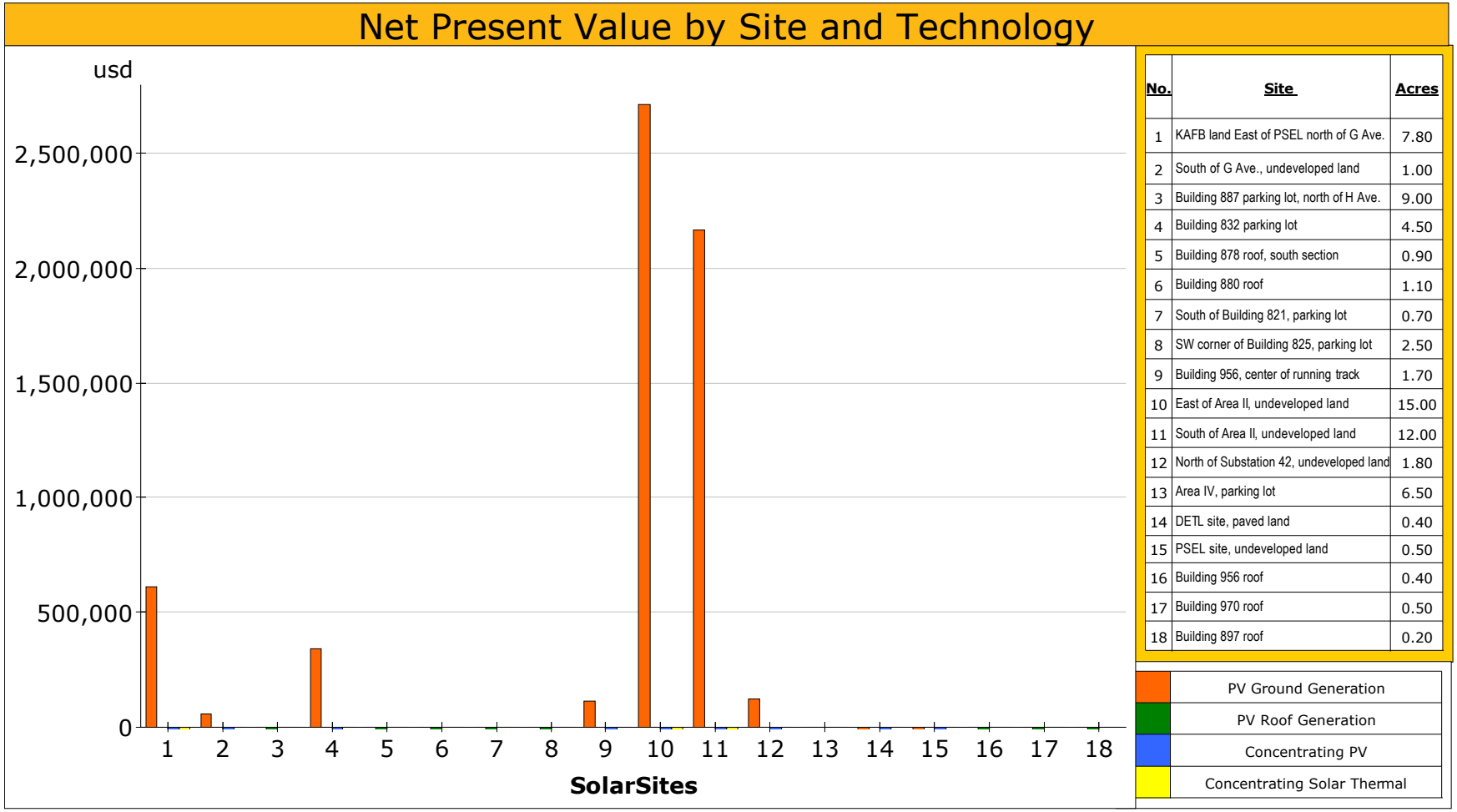
Net present value is negative for this scenario at all sites.

Percent





Scoping-level analysis: all technologies installed to maximum capacity at all appropriate sites in 2014 – **net present value**



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18	Building 897 roof	0.20

Scenario 2:

Evaluate sites with best return on investment (NPV)

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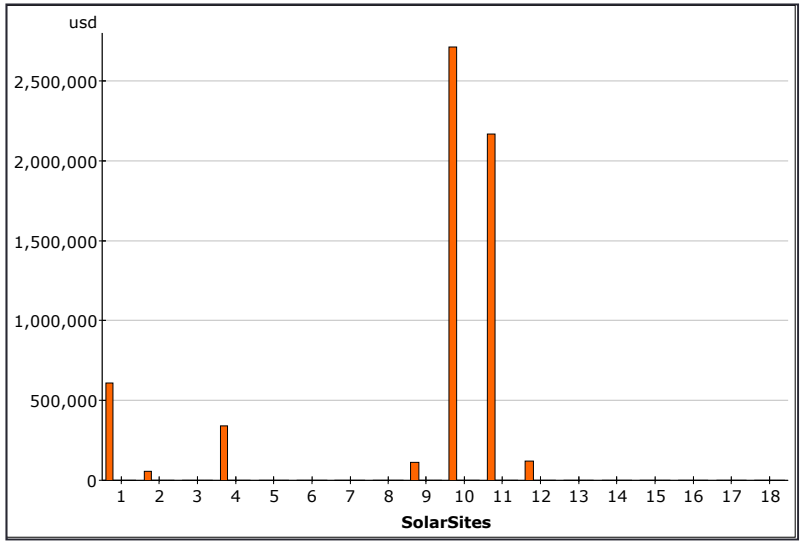
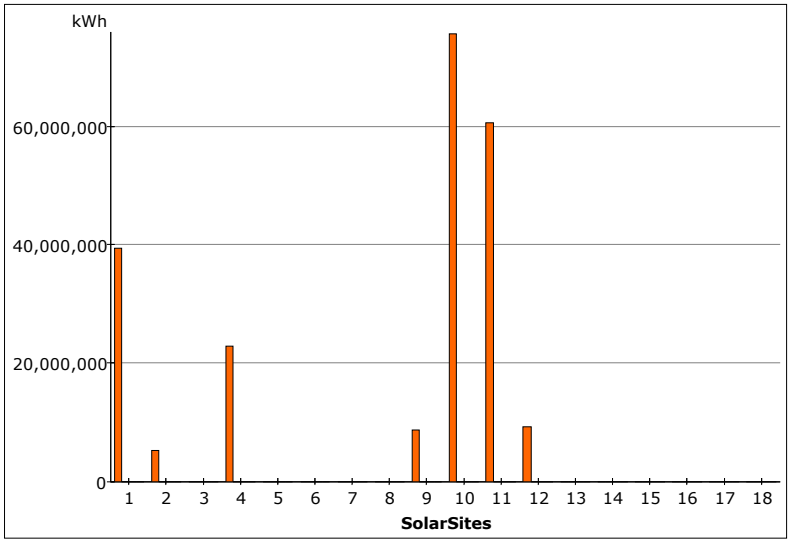
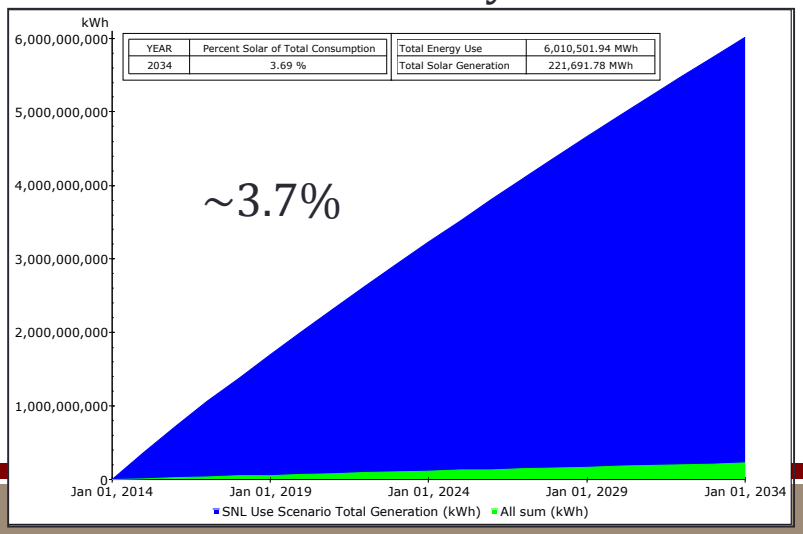
Net Present Value



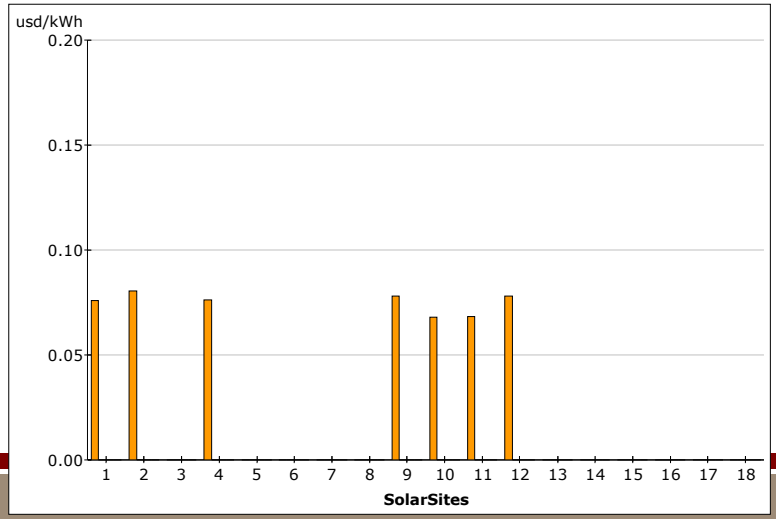
Total Generating Capacity



Percent demand met by solar



Cost per kWh



Demo Scenarios

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Home
User Input
Results
Background
Site Map
Model

MODEL INPUTS

Enter percent installation and start date of solar technologies within installation types guidelines. Note that some installation types are not available at all sites. Types that are unavailable are represented by gray boxes below.

Total % Install must not exceed 100%

	Site Name	Installation Types Available	% Ground PV	Ground PV Start Date	% Roof PV	Roof PV Start Date	% CPV	CPV Start Date	% CST	CST Start Date	Total % Install
1	KAFB land East of PSEL north of G Ave.	Ground PV, CPV, CST	100 %	2014	0 %	2014	100 %	2014	100 %	2014	300 %
2	South of G Ave., undeveloped land	Ground PV, CPV	100 %	2014	0 %	2014	100 %	2014	100 %	2014	300 %
3	Building 887 parking lot, north of H Ave.	Roof PV, CPV	0 %	2014	100 %	2014	100 %	2014	100 %	2014	300 %
4	Building 832 parking lot	Roof PV, CPV	0 %	2014	100 %	2014	100 %	2014	100 %	2014	300 %
5	Building 878 roof, south section	Roof PV, CPV	0 %	2014	100 %	2014	100 %	2014	100 %	2014	300 %
6	Building 880 roof	Roof PV, CPV	0 %	2014	100 %	2014	100 %	2014	100 %	2014	300 %
7	South of Building 821, parking lot	Roof PV, CPV	0 %	2014	100 %	2014	100 %	2014	100 %	2014	300 %
8	SW corner of Building 825, parking lot	Roof PV, CPV	0 %	2014	100 %	2014	100 %	2014	100 %	2014	300 %
9	Building 956, center of running track	Ground PV, CPV	100 %	2014	0 %	2014	100 %	2014	100 %	2014	300 %
10	East of Area II, undeveloped land	Ground PV, CPV, CST	100 %	2014	0 %	2014	100 %	2014	100 %	2014	300 %
11	South of Area II, undeveloped land	Ground PV, CPV, CST	100 %	2014	0 %	2014	100 %	2014	100 %	2014	300 %
12	North of Substation 42, undeveloped land	Ground PV, CPV	100 %	2014	0 %	2014	100 %	2014	100 %	2014	300 %
13	Area IV, parking lot	Roof PV, CPV	0 %	2014	100 %	2014	100 %	2014	100 %	2014	300 %
14	DETL site, paved land	Ground PV, CPV	100 %	2014	0 %	2014	100 %	2014	100 %	2014	300 %
15	PSEL site, undeveloped land	Ground PV, CPV	100 %	2014	0 %	2014	100 %	2014	100 %	2014	300 %
16	Building 956 roof	Roof PV, CPV	0 %	2014	100 %	2014	100 %	2014	100 %	2014	300 %
17	Building 970 roof	Roof PV, CPV	0 %	2014	100 %	2014	100 %	2014	100 %	2014	300 %
18	Building 897 roof	Roof PV, CPV	0 %	2014	100 %	2014	100 %	2014	100 %	2014	300 %

Variables

Derating percent	2.00 %/yr
Reduction in installation costs	-2.00 %/yr
PPA price	0.18 usd/kWh
Federal rebate	30.00 %
Renewable Energy Credit (REC)	0.05 usd/kWh
NM State incentive	0.03 usd/kWh
NM Advanced Energy Credit	6.00 %
Inflation rate	3.00 %

All input variables will retain values determined

Table 1. Site Investigation for Placing PV on the SNL/NM Site

	Sites / Description	Acreage	Technology	MW Capacity	Production MWh/yr
1	KAFB land east of PSEL Undeveloped land north of G Ave.	7.8	Ground-mounted PV	0.98	2187.4
2	South of G Ave. Undeveloped dirt strip of land	1.0	Ground-mounted PV	0.13	280.4
3	Building 887 existing parking lot North of H Ave.	9.0	PV on parking shade structure	1.13	2523.9
4	Building 832 parking lot Existing parking lot and buildings to be removed	4.5	PV on parking shade structure	0.56	1261.9
5	Building 878 roof South section of existing roof	0.9	Roof-mounted PV/PV membrane	0.11	252.4
6	Building 880 roof Center section of existing roof	1.1	Membrane or roof-mounted PV	0.14	308.5
7	South of Building 821 Existing parking lot	0.7	PV on parking shade structure	0.09	196.3
8	SW Corner Building 825 parking lot Existing parking lot	2.5	PV on parking shade structure	0.31	701.1
9	Building 956 running track Center of existing running track	1.7	Ground-mounted PV	0.21	467.7
10	East end of Area II Undeveloped land on top of escarpment	15.0	Ground-mounted PV	1.88	4206.4
11	South end of Area II Undeveloped land north of R Ave.	12.0	Ground-mounted PV	1.51	3365.2
12	North of Substation 42 Undeveloped land south of R Ave. and east of 9th St.	1.8	Ground-mounted PV	0.23	504.8
13	Area IV parking lot Existing parking lot south of S Ave. and east of 9th St.	6.5	PV on parking shade structure	0.81	1822.8
14	DETL site Paved land east of MO 290 and south of F Ave.	0.4	Ground-mounted PV	0.05	112.2
15	PSEL site Undeveloped land at north edge of PSEL site	0.5	Ground-mounted PV	0.06	140.2
16	Building 956 roof Center section of existing roof	0.4	Roof-mounted PV/PV membrane	0.05	112.2
17	Building 970 roof East section of existing roof	0.5	Roof-mounted PV/PV membrane	0.06	140.2
18	Building 897 roof South section of existing roof	0.2	Roof-mounted PV/PV membrane	0.03	56.1
		Totals 66.9		8.34	18639.7

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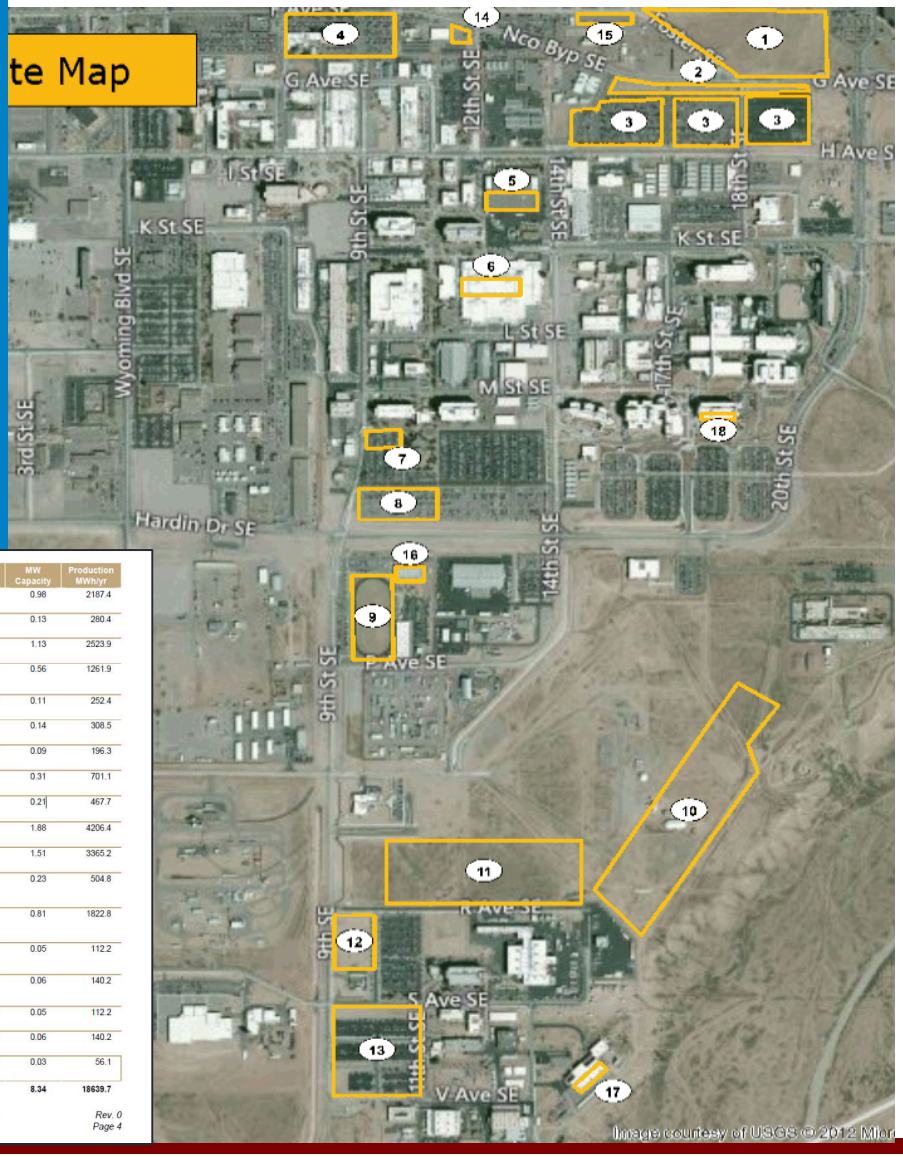

Wrap-Up

Conclusions

- SNL saw a need and invested in IX, a campus wide analysis tool
- Benefits of IX are:
  - Capital Investments
  - Operations and Controls
    - Efficiency of Operations
    - Policy Changes
  - Measurement and Verification
  - Renewable Energy Evaluation

Enables fact-based conversation and decisions with Peers and Upper Management

- Future Plans
  - New user interface
  - Additional Modules: energy storage; transportation; water; materials management

Contact Information

Sandia National Laboratories

- Jack Mizner
- Howard Passell
- Daniel Villa