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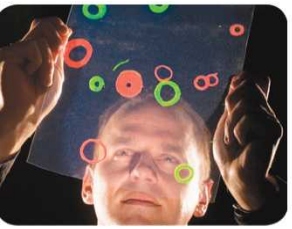

Sandia National Laboratories

Exceptional service in the national interest

Institutional Transformation (IX)

Toolkit to Inform Energy Conservation and Sustainability Decisions Campus-wide

Jerry McNeish
Sandia National Laboratories

SUSTECH 2014
Portland, Oregon
July 2014

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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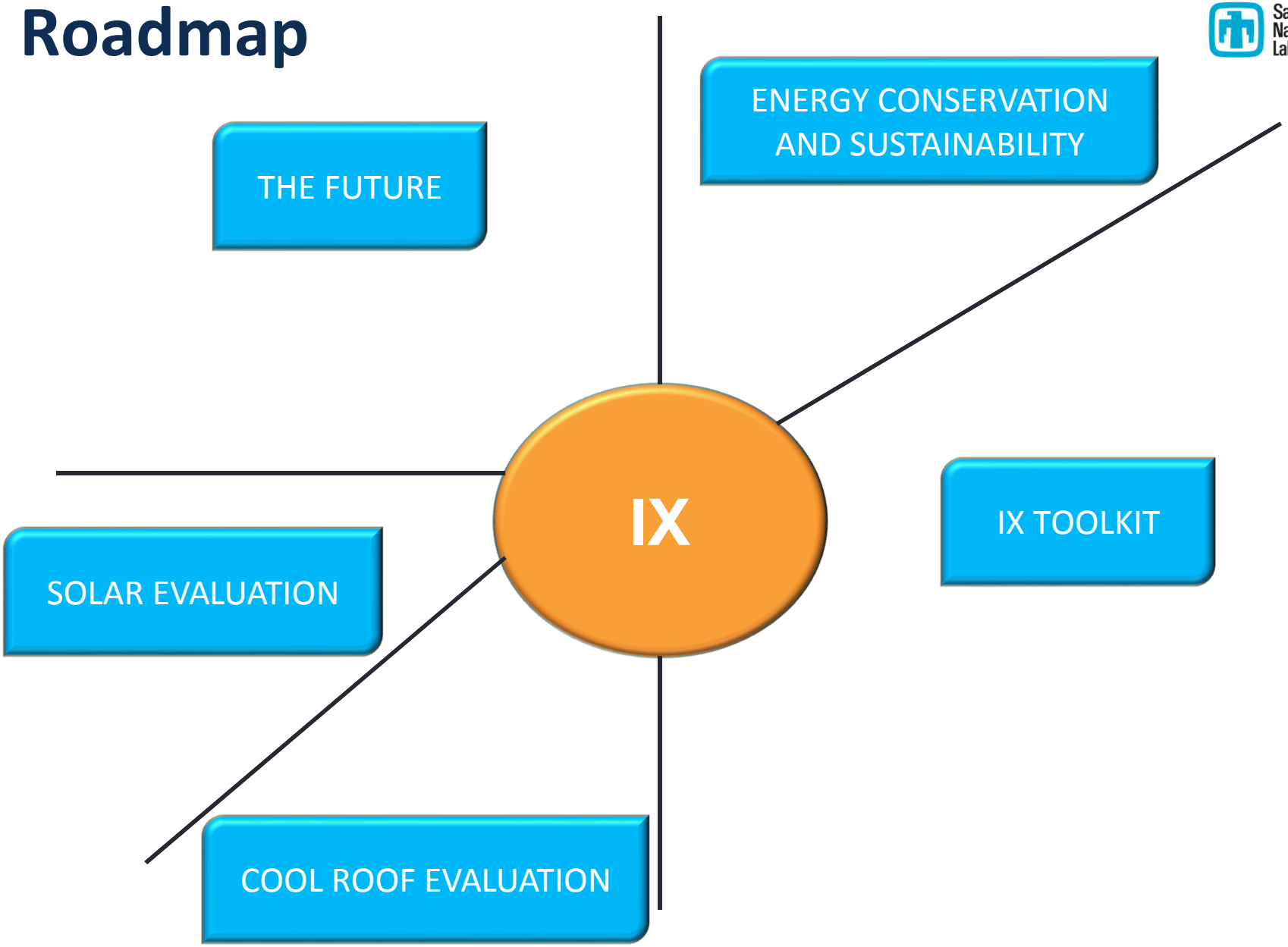
Roadmap


ENERGY CONSERVATION AND SUSTAINABILITY
THE FUTURE
IX
IX TOOLKIT
SOLAR EVALUATION
COOL ROOF EVALUATION

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Energy Conservation and Sustainability

The Opportunity

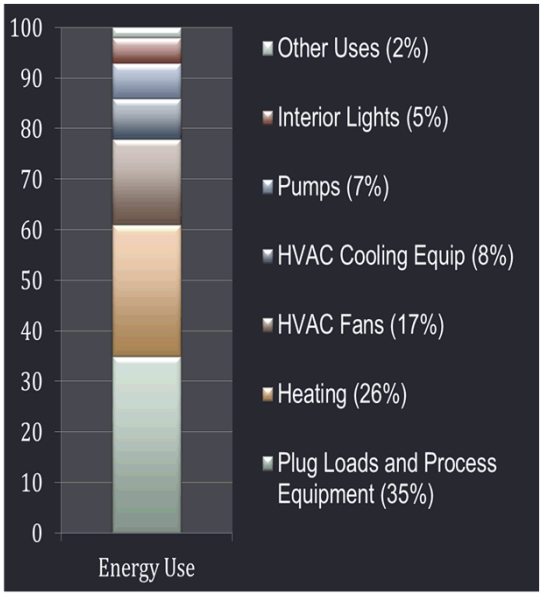
- Sandia allocated funding over a few years for a number of sustainability related projects

The Vision

- **Transform** Sandia facilities and practices toward sustainability and energy conservation
- Take a **systems level** approach to the transformation
- Incorporate new **sustainability science** and data collection
- Provide analysis to **inform decision makers**

Sandia

- 2 campuses
- 11,000+staff
- BIdgs
  - [legacy and new]
- Energy use



Context

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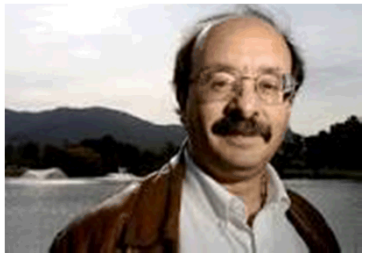
How can Sandia meet:

- Energy Reduction Goals
  - 30% Energy Intensity (DOE)
  - 25% Energy Reduction (SNL)
  - Future Challenges
- Federal High Performance Sustainable Building Goals
  - Building Energy Reduction
  - ASHRAE 55/62 [thermal comfort; healthy air ventilation]
- Renewable Energy Goals
  - 20% by 2020



Accomplishments

- **Reduced energy use by over 9% in less than 3 years**
- **Saved $7.5 million in energy costs; ($2 million from conservation)**
- **Specifically,**
  - Improved central plant efficiency: free-cooling heat exchangers; magnetic bearing chillers
  - Improved building operations through better control of building operating systems
  - Installed vacancy/occupancy sensors for lighting and HVAC.
  - Improved the rigor in energy audits and retro-commissioning
  - Developed a campus energy model that identifies energy end uses and additional opportunities (IX)

Institutional Transformation (IX) Toolkit

What is the IX Toolkit?

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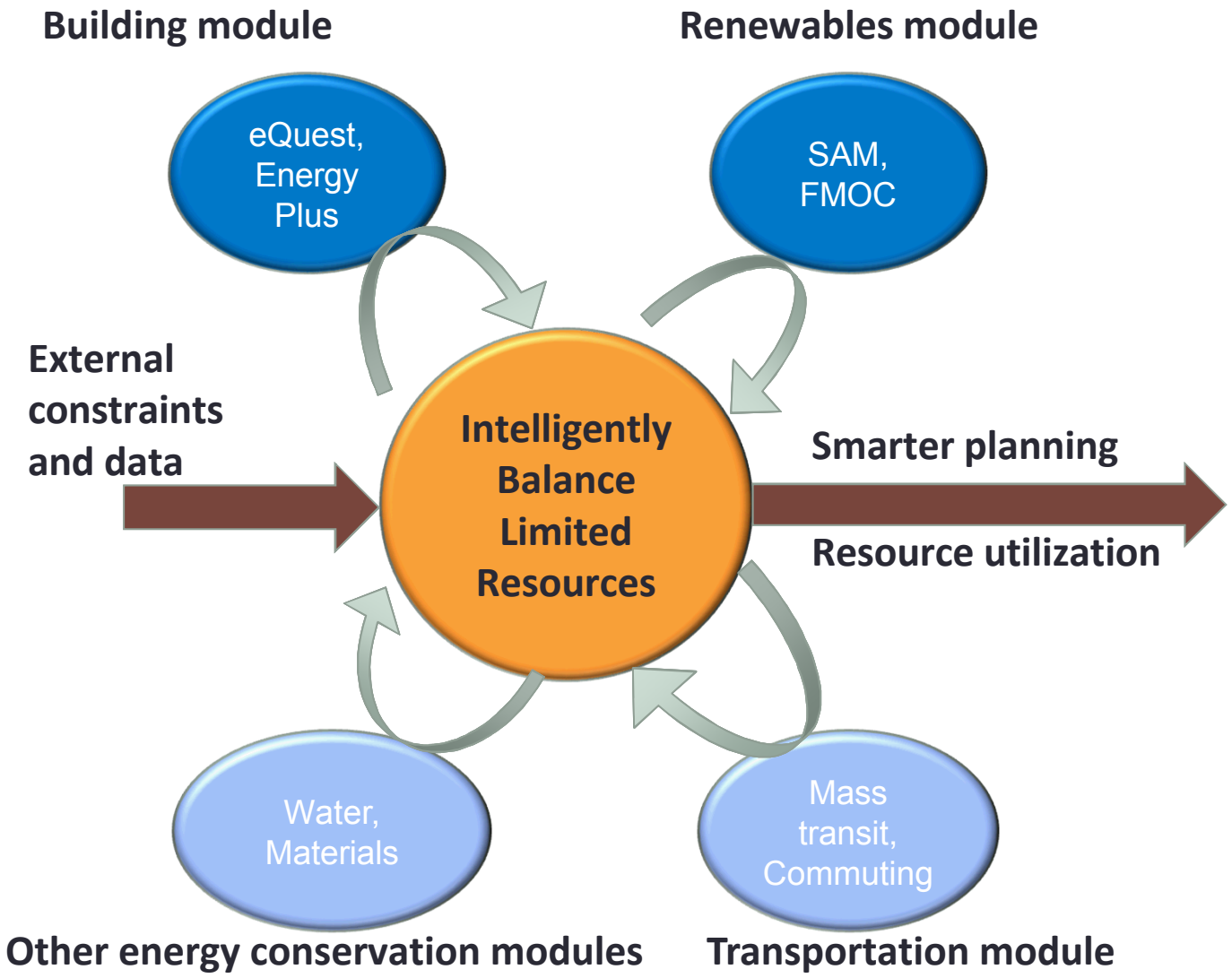
- **Purpose:** Select and evaluate cost-effective Energy Conservation Measures (ECMs), Operational Conservation Measures (OCMs) and Renewable Energy options at a system level
- **Toolkit:** An engineering tool that integrates DOE-produced software (eQUEST, DOE2, SAM) into Excel to inform strategic capital planning and operational decisions
- **Evaluations:** Multiple ECMs and OCMs in multiple buildings over multiple years
- **Team:** Collaboratively developed by SNL, university faculty (ASU) and NM engineering firm (Bridgers and Paxton, Inc.).

Credits: The IX Team

Sandia National Laboratories

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

IX Vision Conceptual Diagram



Outcomes:

1. Well informed integrated assessment for investment toward 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 decisionmakers.

How to Use IX

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

IX Toolkit: Current features

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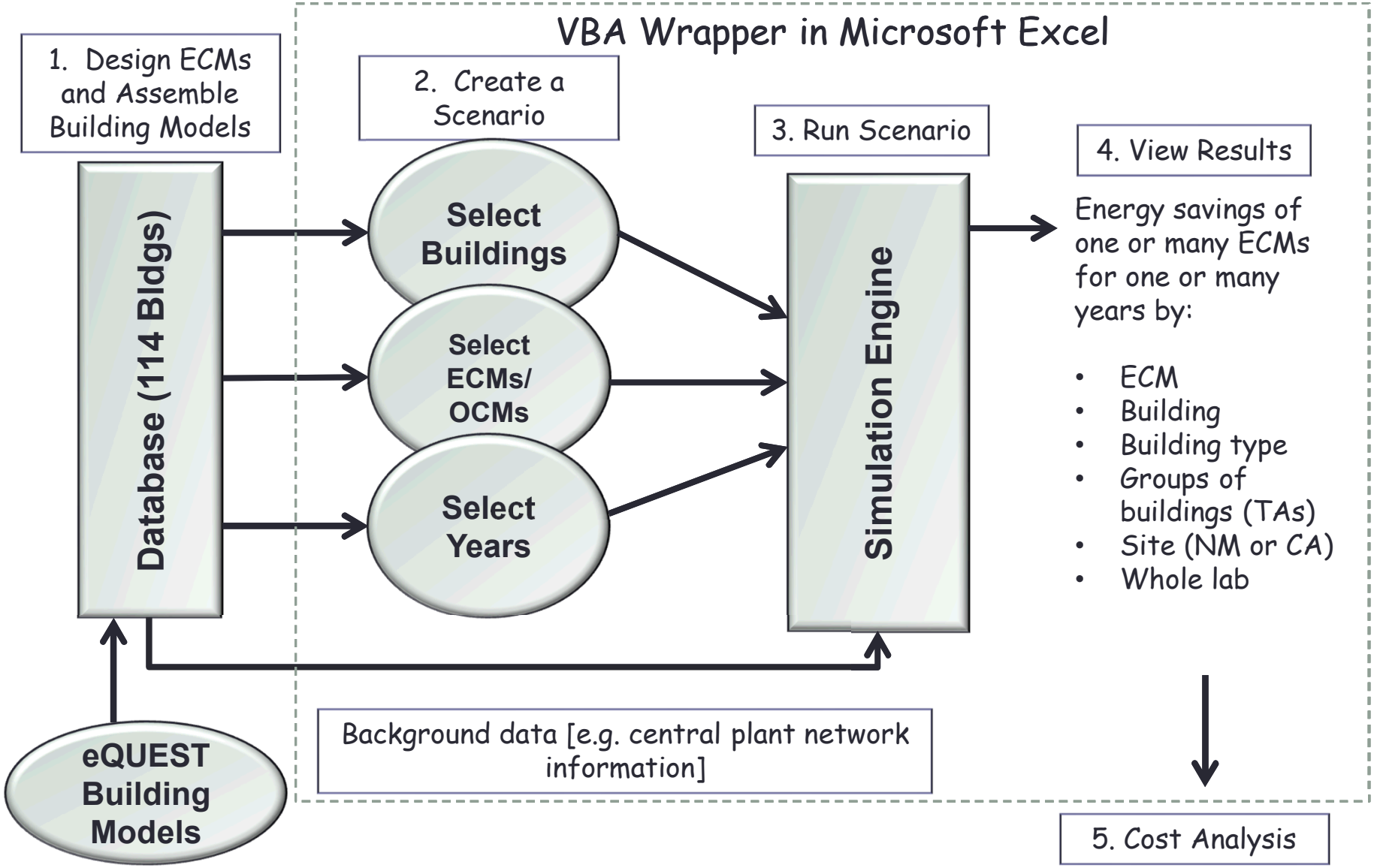
- 114 building models in eQUEST
  - All Buildings on site > 10,000 ft^2 (> 90% of total energy consumption)
  - Building types: Office, Light Laboratory, Heavy Laboratory, Data center, Auditorium, Cafeteria, Warehouse, Education, Medical
- 24 ECMs/OCMs with capacity for creating new ECMs/OCMs
- Incorporating Central Plants
- Tracks building changes over years
- Solar evaluation module

Building Module Software Architecture



IX Planning Decision Support

IX Results

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Version 4 (FINAL)		Site-Wide Percent Energy Saved			Site-Wide Energy Savings		
ECM	Description*	Electricity (%)	Gas (%)	Total (%)	Electricity (MBTU)	Gas (MBTU)	Total (MBTU)
Lab Exhaust	25% reduction in flow during unoccupied hours in all eligible buildings	0.65%	3.59%	1.75%	5.14E+03	1.70E+04	2.22E+04
	50% reduction in flow during unoccupied hours in all eligible buildings	1.08%	8.32%	3.79%	8.53E+03	3.94E+04	4.79E+04
Reduce Illumination Levels	20% Reduction in Average Lighting Power Density	1.35%	-0.98%	0.48%	1.07E+04	-4.66E+03	6066.133145
Supply Air Temperature and Chilled Water/Hot Water Resets	Add chilled and hot water resets to all buildings that need one	0.10%	-0.03%	0.05%	784.1871072	-126.181071	658.0060362
	Add supply air temperature reset to all buildings that need one	0.82%	2.77%	1.55%	6497.494972	13134.55702	19632.05199
	Add both reset types	0.92%	2.75%	1.60%	7289.032754	13008.26228	20297.29503
Reduce Fan Operations Hours And Change Thermostat Settings	Converted 24-7 to Normal Operations**: Reduce Fan Ops	2.49%	2.82%	2.61%	19703.69186	13358.36081	33062.05267
	Converted 24-7 to Normal Operations**: Thermostat Changes	0.12%	0.51%	0.26%	938.615024	2394.99594	3333.610964
	Converted 24-7 to Normal Operations**: Both	2.95%	3.74%	3.25%	23399.12774	17709.1709	41108.29864
	Offices: Reduced Fan Operations	0.01%	0.03%	0.02%	106.1182645	162.976091	269.0943555
	Offices: Thermostat Changes	0.20%	0.83%	0.44%	1603.296055	3925.166804	5528.462859
	Offices: Both	0.22%	0.89%	0.47%	1780.887434	4190.688286	5971.57572
	Labs: Reduced Fan Operations	0.20%	0.57%	0.34%	1604.936681	2709.245508	4314.182189
	Labs: Thermostat Changes	1.50%	25.81%	10.59%	11907.0197	122196.5032	134103.5229
	Labs: Both	1.73%	26.36%	10.94%	13704.91287	124816.3566	138521.2694
	Other Buildings: Reduced Fan Operations	0.04%	0.02%	0.03%	319.7327529	95.716851	415.4496039
	Other Buildings: Thermostat Changes	0.17%	0.21%	0.18%	1328.388065	1000.787285	2329.17535
	Other Buildings: Both	0.21%	0.23%	0.22%	1631.437627	1097.01898	2728.456607
Total		5.51%	37.56%	**20.74%**	4366148.14%	17786487.74%	22152635.88%

* See the following link for detailed descriptions of the ECMs. Many buildings were excluded from application of an ECM because the measure has already been implemented. Building level % energy savings are available on the ECM energy pages from which th

** This group included the following offices/light laboratories: 751, 755, 868, 887, 6584, 810, 858S, 858EL, 897, 891, 898, 894, 755, 868

Path Forward – Facilities Management Operations Center Opportunities

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Initiative	Savings	YR	Strategy
FCS Programming	1-2 % Improves Operations and Performance	14	Conduct Structure Improvement Activity (SIA)
Calibrate Control Sensors		14	Work with FCS to identify key control sensors and develop plan for calibration/replacement
Energy Analytics		14-16	Procure contract; develop operational rules and implement
Improve Metering Program	None	14 - 15	Work with 4821 to identify needs and develop plan. Incorporate into Annual Site Metering Plan
Operational changes: CHW, HW and SAT reset	1-1.5 %	14 - 15	Implement immediately through FCS programming. Transparent to line organizations
Lighting	0.5%	TBD	Capital funding. Poor ROI. Not included in total.
Renewable Energy: Solar Hot Water Systems	TBD	14-16	Continue to explore PV projects, including 3rd party financing. Finalizing design for Bldg. 823
Implement high ROI projects	4.5 -6 %	14-16	Use IX to identify and fund projects with the greatest return, including line projects

Potential Additional Reduction: 6.5% - 9.5%

Path Forward – Line Opportunities

Initiative	Savings	YR	Strategy
Office (Temp Set Point; Operating Hours)	1 – 1.5 %	14	Change Procedures and Service Level Agreement; Communication Plan Implement in June
Labs (Temp Set Point; Operating Hours)	3-7 %	14-15	Lab Pilot in Bldg 701. White Paper, Policy and Communication Plan Implement in labs individually, based on mission
Ventilation Setback in Labs (unoccupied hours)	2-3 %	15-17	
Fume Hood Management	TBD	14-16	Valve off unused fume hoods. Optimize fume hood flow rates, and applications. Consider pilot (e.g., Bldg. 823)
Eliminate Unneeded 24/7 Operations	2-3 %	14-17	Identify and prioritize buildings and work with mission occupants individually in each building
Clean Room Improvements	TBD	14-17	Management communication and support; Identify projects in Energy Audit
Process Equipment	TBD	14-17	Pilot 986; project identification and implementation
Compressed Air	TBD	15	Study this year. Fund high ROI projects in FY15

Potential Additional Reduction: 8.0% – 14.5 %

IX Cool Roof
SNL Site-Wide Results

Cool Roof Evaluation

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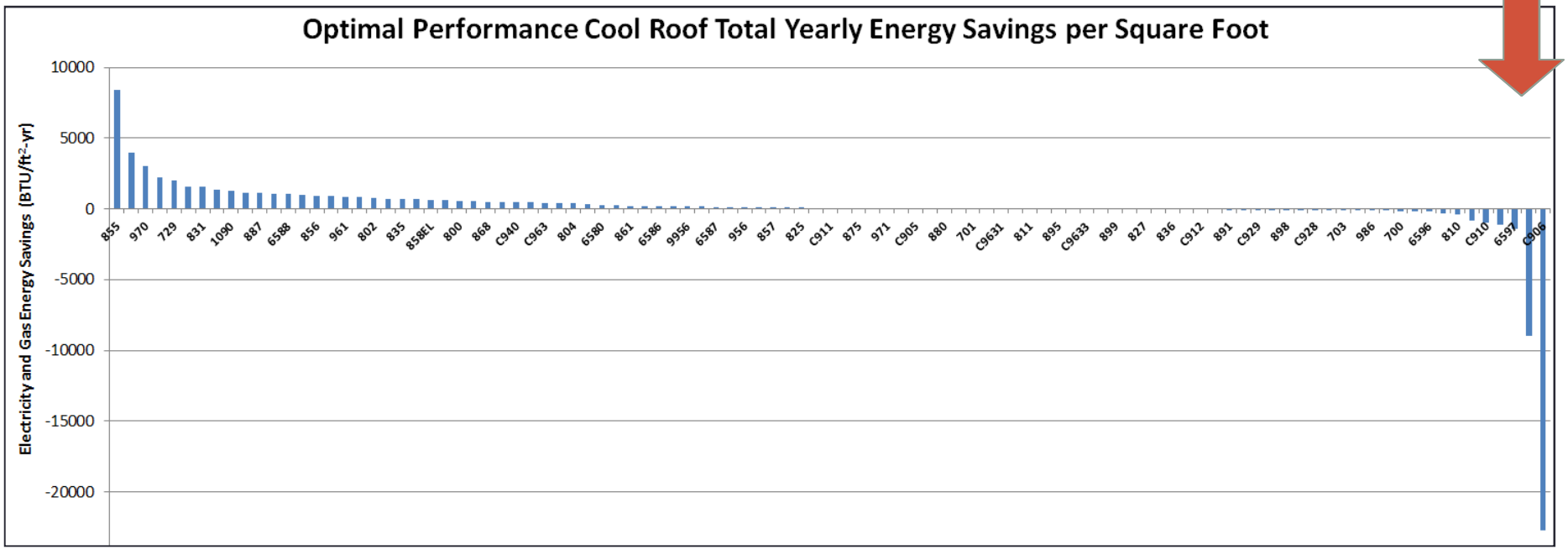
- **Purpose:** Use IX Building Module for ECM evaluation of an entire site [NM]
- **Planning Objectives:**
  - Apply a new cool roof to buildings in the order which saves the maximum amount of energy over time with a limited budget
  - Simultaneously bring any non-compliant insulation of roofs up to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

Are Cool Roofs Cost-Effective?

- Apply insulation and cool roof to 114 buildings and run 1 year
- Sort the total energy savings for 114 buildings from highest to lowest
- Cool roofs do not always save energy for the SNL/NM site



Optimal Cool Roof Installation

- 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 with better technology

Pink: Solar Reflective Index ~ 105-115

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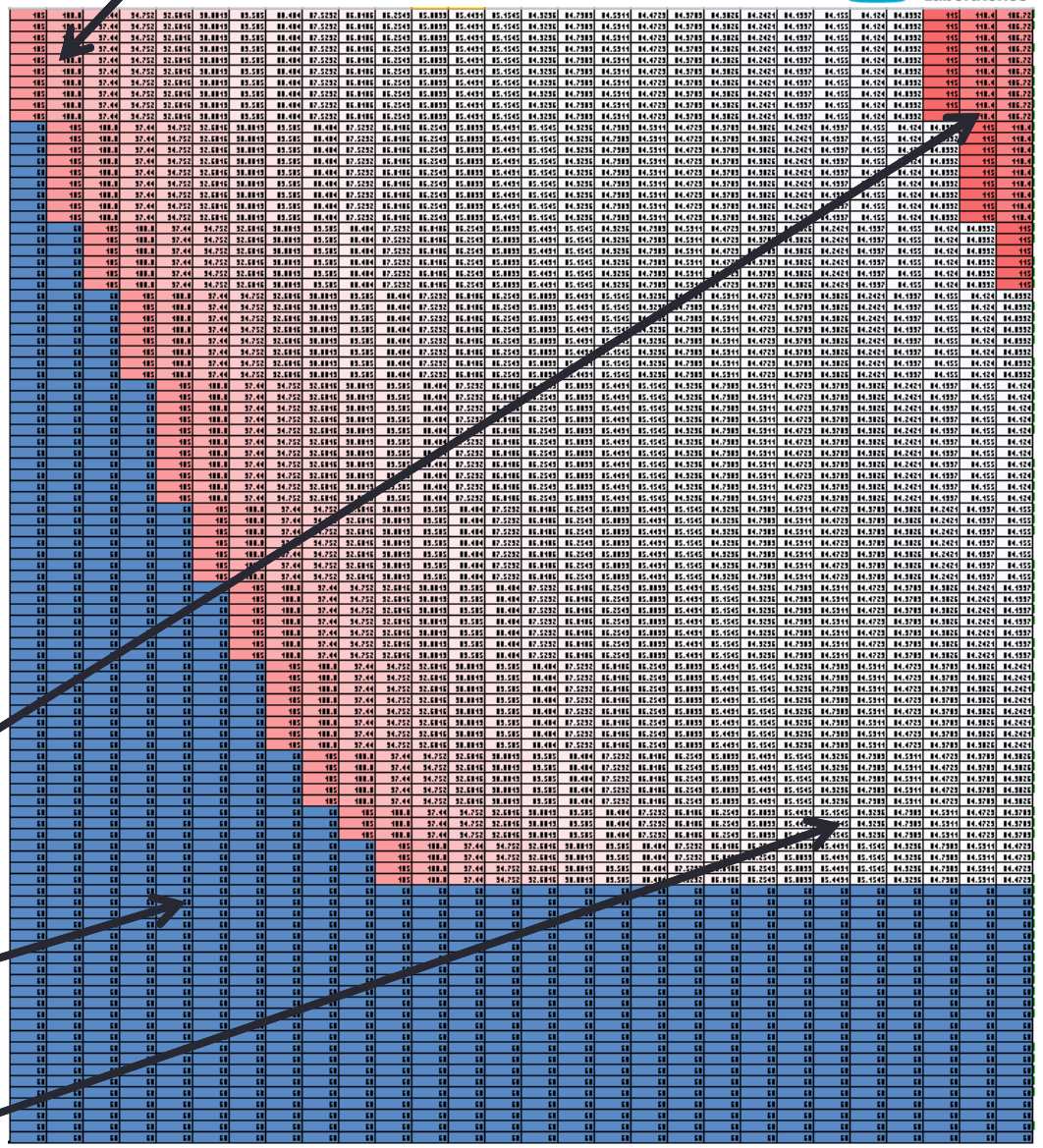
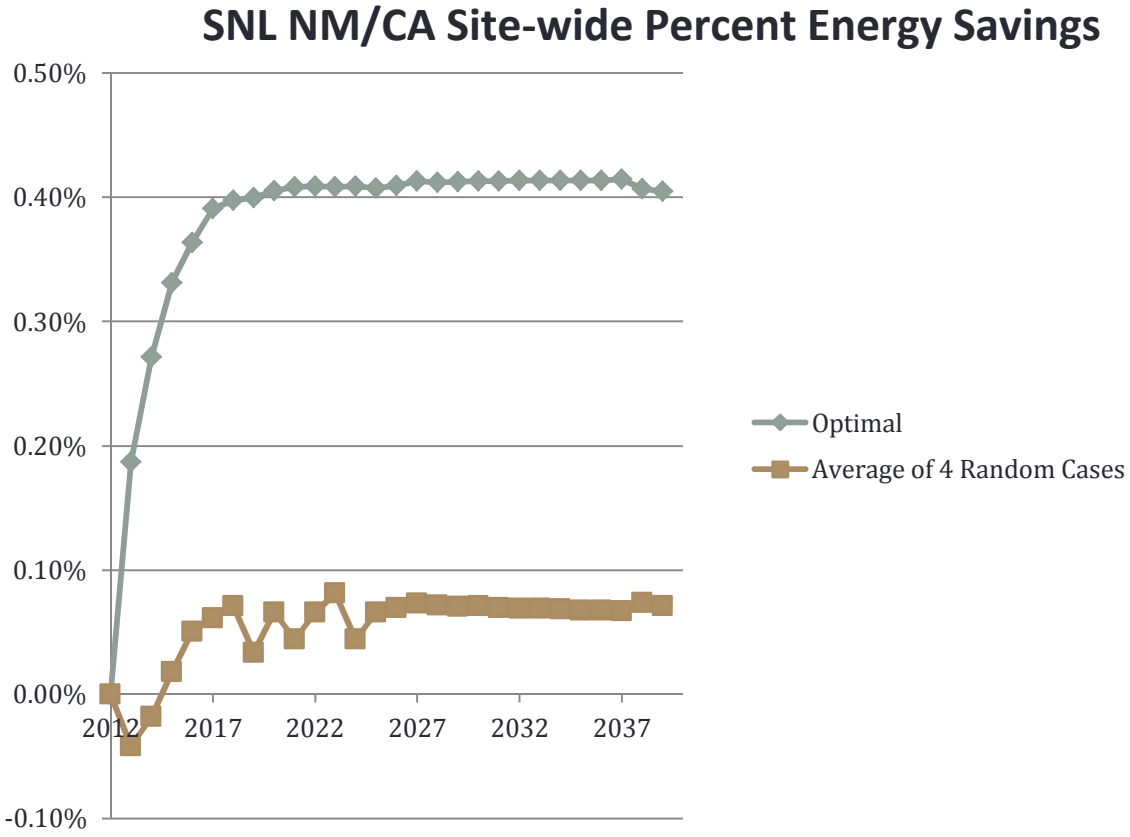


Percentage Savings

- Site-wide energy savings for applying a cool roof surface with additional insulation is only 0.4%
- If cool roof and insulation costs are high, other ECMs may be more desirable



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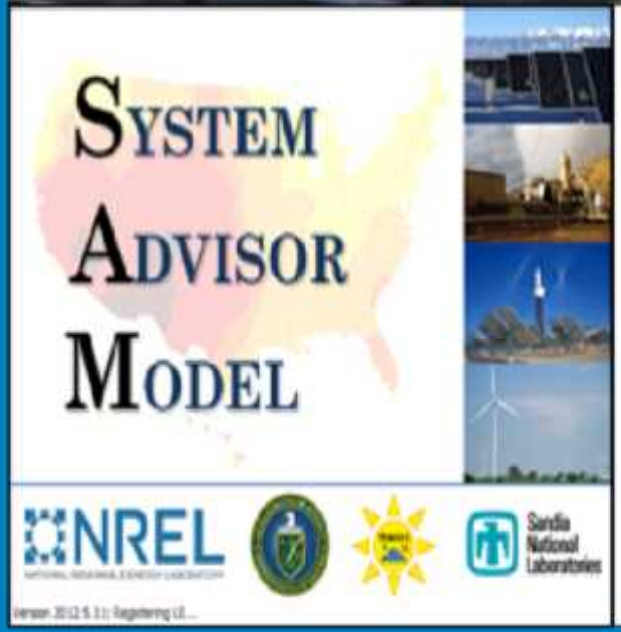
IX Solar Energy
SNL Site-Wide Results

Home
User Input
Results
Background
Site Map
Model

IX Solar Installations
Draft Model



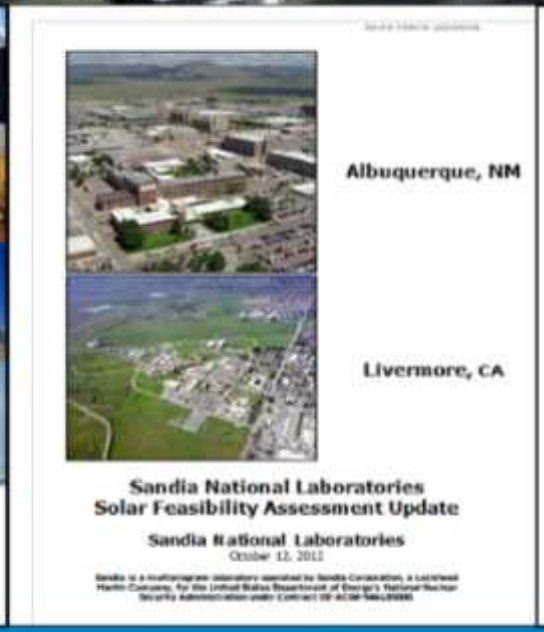


Table 1. Site Investigation for Placing PV on the SNL/NM Site

	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)

Screening analysis

-4 solar technologies installed to max capacity

-Scenario includes increasing electricity cost

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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.

It is best if the Total % Install does not exceed 100%

	Site Name	Area (acres)	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.	7.80 acres	Ground PV, CPV, CST	100 %	1/1/2014	0 %	1/1/2014	100 %	1/1/2014	100 %	1/1/2014	300 %
2	South of G Ave., undeveloped land	1.00 acre	Ground PV, CPV	100 %	1/1/2014	0 %	1/1/2014	100 %	1/1/2014	0 %	1/1/2014	200 %
3	Building 887 parking lot, north of H Ave.	9.00 acres	Roof PV, CPV	0 %	1/1/2014	100 %	1/1/2014	0 %	1/1/2014	0 %	1/1/2014	100 %
4	Building 832 parking lot	4.50 acres	Roof PV, CPV	100 %	1/1/2014	0 %	1/1/2014	100 %	1/1/2014	0 %	1/1/2014	200 %
5	Building 878 roof, south section	0.90 acres	Roof PV, CPV	0 %	1/1/2014	100 %	1/1/2014	0 %	1/1/2014	0 %	1/1/2014	100 %
6	Building 880 roof	1.10 acres	Roof PV, CPV	0 %	1/1/2014	100 %	1/1/2014	0 %	1/1/2014	0 %	1/1/2014	100 %
7	South of Building 821, parking lot	0.70 acres	Roof PV, CPV	0 %	1/1/2014	100 %	1/1/2014	0 %	1/1/2014	0 %	1/1/2014	100 %
8	SW corner of Building 825, parking lot	2.50 acres	Roof PV, CPV	0 %	1/1/2014	100 %	1/1/2014	0 %	1/1/2014	0 %	1/1/2014	100 %
9	Building 956, center of running track	1.70 acres	Ground PV, CPV	100 %	1/1/2014	0 %	1/1/2014	100 %	1/1/2014	0 %	1/1/2014	200 %
10	East of Area II, undeveloped land	15.00 acres	Ground PV, CPV, CST	100 %	1/1/2014	0 %	1/1/2014	100 %	1/1/2014	100 %	1/1/2014	300 %
11	South of Area II, undeveloped land	12.00 acres	Ground PV, CPV, CST	100 %	1/1/2014	0 %	1/1/2014	100 %	1/1/2014	100 %	1/1/2014	300 %
12	North of Substation 42, undeveloped land	1.80 acres	Ground PV, CPV	100 %	1/1/2014	0 %	1/1/2014	100 %	1/1/2014	0 %	1/1/2014	200 %
13	Area IV, parking lot	6.50 acres	Roof PV, CPV	100 %	1/1/2014	0 %	1/1/2014	0 %	1/1/2014	0 %	1/1/2014	100 %
14	DETL site, paved land	0.40 acres	Ground PV, CPV	100 %	1/1/2014	0 %	1/1/2014	100 %	1/1/2014	0 %	1/1/2014	200 %
15	PSEL site, undeveloped land	0.50 acres	Ground PV, CPV	100 %	1/1/2014	0 %	1/1/2014	100 %	1/1/2014	0 %	1/1/2014	200 %
16	Building 956 roof	0.40 acres	Roof PV, CPV	0 %	1/1/2014	100 %	1/1/2014	0 %	1/1/2014	0 %	1/1/2014	100 %
17	Building 970 roof	0.50 acres	Roof PV, CPV	0 %	1/1/2014	100 %	1/1/2014	0 %	1/1/2014	0 %	1/1/2014	100 %
18	Building 897 roof	0.20 acres	Roof PV, CPV	0 %	1/1/2014	100 %	1/1/2014	0 %	1/1/2014	0 %	1/1/2014	100 %

Evaluation of sites with highest generating capacity

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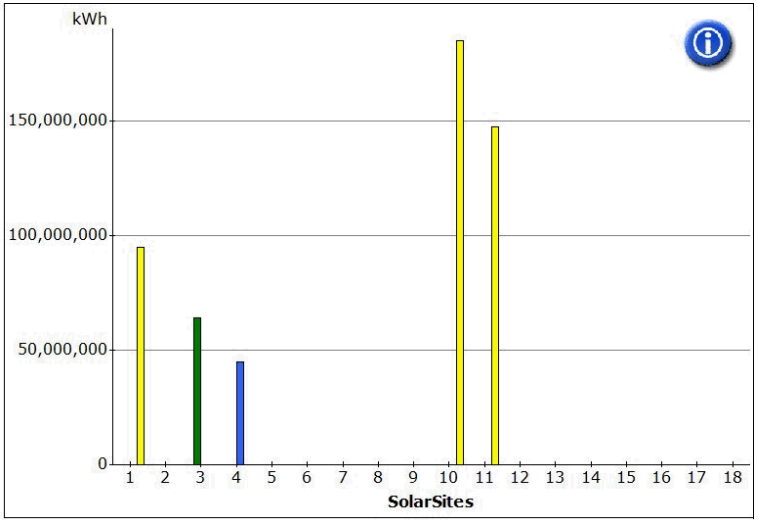
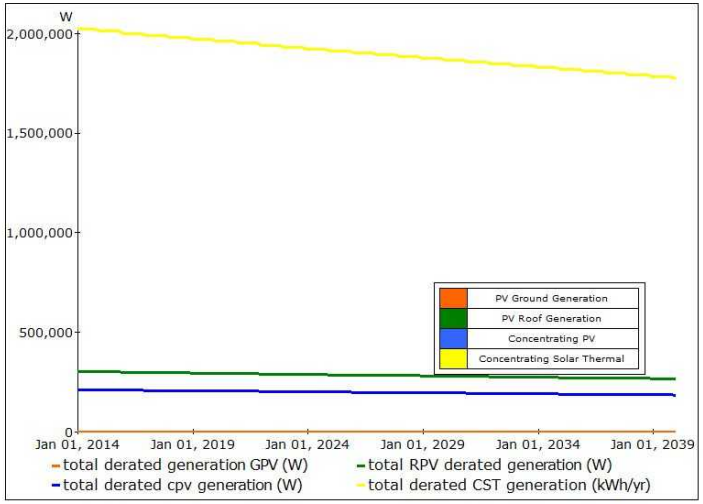
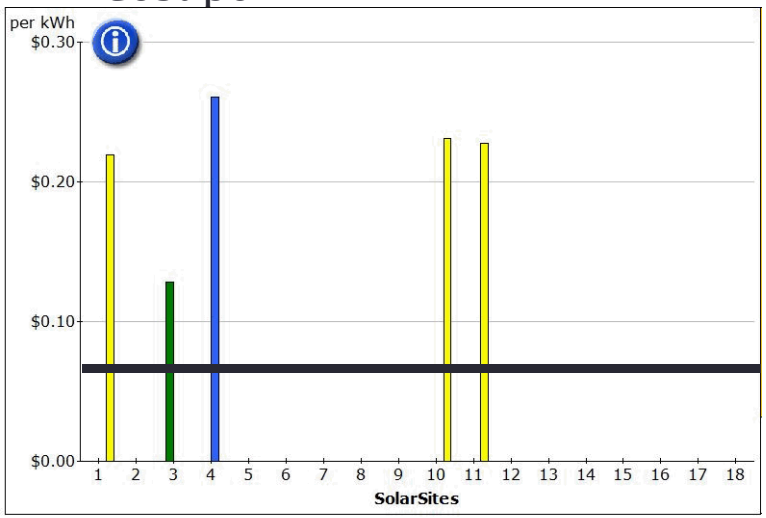
Total Generating Capacity



Percent demand met by solar – 11.86%



Cost per kWh



USD per Watt Installed

Site No.	PV - ground	PV - roof	CPV	CST
1	$0.00 per W	$0.00 per W	$0.00 per W	$12.59 per W
2	$0.00 per W	$0.00 per W	$0.00 per W	$0.00 per W
3	$0.00 per W	$4.56 per W	$0.00 per W	$0.00 per W
4	$0.00 per W	$0.00 per W	$9.57 per W	$0.00 per W
5	$0.00 per W	$0.00 per W	$0.00 per W	$0.00 per W
6	$0.00 per W	$0.00 per W	$0.00 per W	$0.00 per W
7	$0.00 per W	$0.00 per W	$0.00 per W	$0.00 per W
8	$0.00 per W	$0.00 per W	$0.00 per W	$0.00 per W
9	$0.00 per W	$0.00 per W	$0.00 per W	$0.00 per W
10	$0.00 per W	$0.00 per W	$0.00 per W	$12.59 per W
11	$0.00 per W	$0.00 per W	$0.00 per W	$12.59 per W
12	$0.00 per W	$0.00 per W	$0.00 per W	$0.00 per W
13	$0.00 per W	$0.00 per W	$0.00 per W	$0.00 per W
14	$0.00 per W	$0.00 per W	$0.00 per W	$0.00 per W
15	$0.00 per W	$0.00 per W	$0.00 per W	$0.00 per W
16	$0.00 per W	$0.00 per W	$0.00 per W	$0.00 per W
17	$0.00 per W	$0.00 per W	$0.00 per W	$0.00 per W
18	$0.00 per W	$0.00 per W	$0.00 per W	$0.00 per W

Sandia National Laboratories

The Future

Where we are

Sandia National Laboratories

- Sandia has invested in IX, an engineering toolkit for system level prioritization
- System level approach is proving useful and can potentially 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
- Solar power technologies evaluation determined they are currently not cost effective in NM
- Lays a groundwork for smart buildings and institutions

Where we want to go [v3.0]

Sandia National Laboratories

- Develop new modules
  - transportation alternatives
  - material flows/water conservation
  - energy storage options
  - other renewable energy sources
  - life cycle cost estimates/ROI
- Improve user interface and module integration
- With open-sourcing, use IX for other large institutions [national labs, military bases, city/state/federal government complexes, industrial complexes]
  - Funded by NNSA to pilot IX at LANL
- Seek collaboration with Universities and others

The Journey

Sandia National Laboratories

Backup

Sandia National Laboratories

Questions

Sandia National Laboratories

- Contact information:

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LinkedIn