SOLAR AND ENERGY STORAGE A GLIMPSE AT THE FUTURE

Presented by Doug Danley Tech Liaison – Renewables

National Rural Electric Cooperative Association Nebraska Wind and Solar Conference November 2015



Topics

How consumers and utilities view the future

Electric co-ops and solar

Energy Storage

Open Modeling Framework

The future

First, some perspective ...

How consumers and utilities view the future

Electric co-ops and solar

Energy Storage

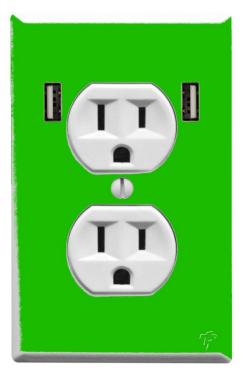
Open Modeling Framework

The future











HomeKit





And now, the view from the other side...



Smart Meter pushback.

Rate Reforms

Smart Meter pushback.

EPA 111(d) Regulated Carbon Emissions

Rate Reforms

Renewable Portfolio Standards

Smart Meter pushback.

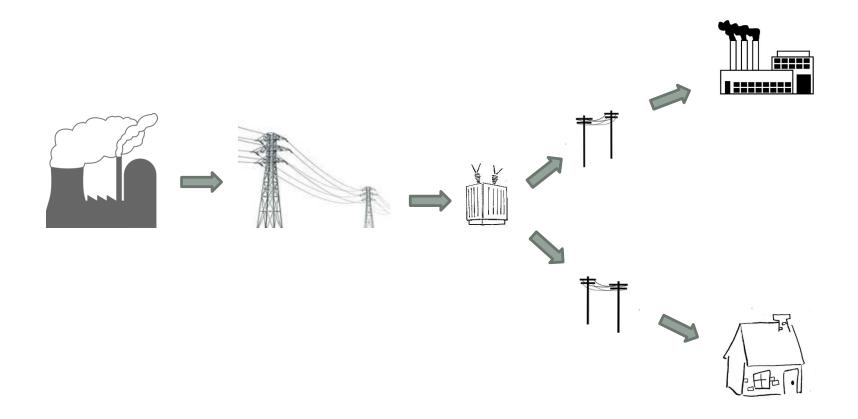
EPA 111(d) Regulated Carbon Emissions

Rate Reforms

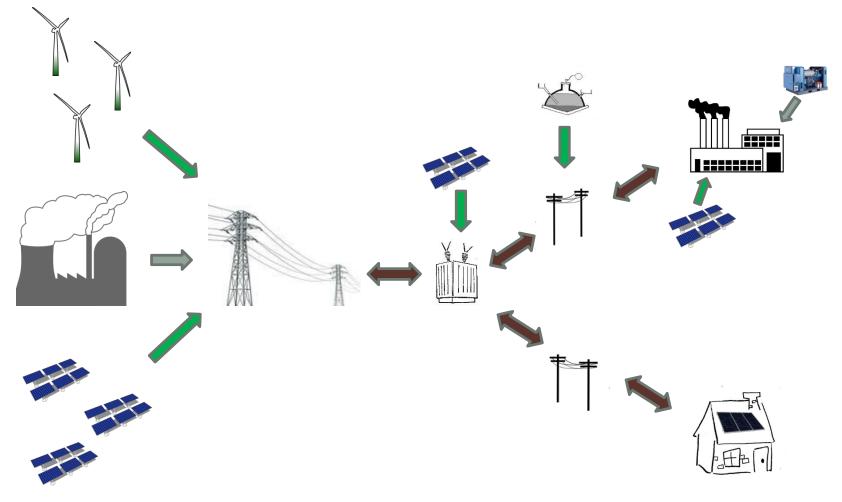
Renewable Portfolio Standards If a train is coming at you, closing your eyes won't save you ... but if you look right at it, you at least have a chance to jump. - Andrew Vachss



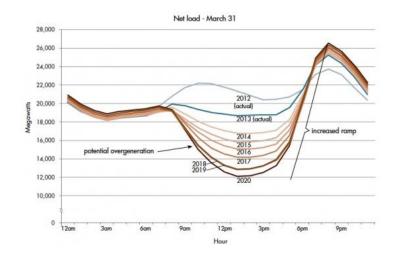
The Electric Grid: 1880-2000

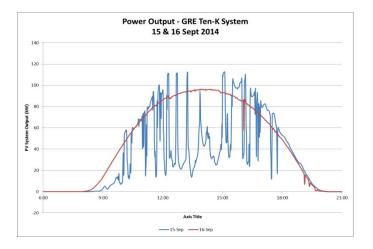


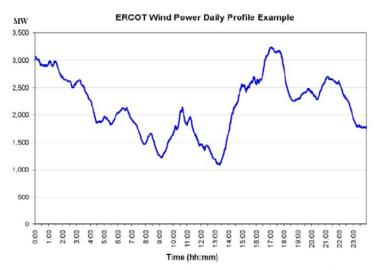
The Electric Grid: 2000-2015



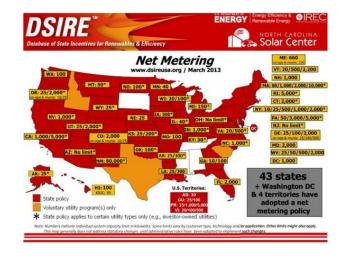
Issues with the Modern Grid







(from NREL's Analysis of Wind Power Ramping Behavior...)



The Electric Grid: 2015-?? MicroGrid TESLA Load SAFT Defection? FA

Back to the main topic ...

How consumers and utilities view the future

Electric co-ops and solar

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Co-op Solar in the News

Eau Claire utility proposes community solar program



SOLAR UTILITY NETWORK DEPLOYMENT ACCELERATION <u>www.nreca.coop/sunda</u>

Four year DOE-funded project to reduce co-op barriers to utility-scale PV.

Template engineering designs for MW-scale systems. System cost templates and financing guides. Consolidated purchasing.

> Utility PV Field Manual, Multi-level Training and Outreach

SUNDA Partners

Anza Electric Co-op (CA) Brunswick EMC (NC) CoServ Electric (TX) Eau Claire Energy Co-op (WI) Great River Energy + Wright Hennepin (MN) Green Power EMC/Oglethorpe (GA) North Arkansas Electric Co-op (AR) Owen Electric Co-op (KY) Pedernales Electric Co-op (TX) Sandhills Utility Services (NC) Sussex Rural Electric Co-op (NJ) Tri-State G&T Assn. (CO and others) Vermont Electric Co-op (VT)





Solar Energy Solutions

FEDERATED RURAL ELECTRI INSURANCE EXCHANGE

SUNDA Tools – Help to Get Started

Cooperative Utility PV Field Manual

Volume I

Business Models and Financing Options

How-To Manuals Business models/Financing Design/Install/Interconnect Operations/Maintenance

VOLUME 1. DUSINESS INIQUELS AND FINANCING OFTIONS

VOLUME II: PLANNING, DESIGN, INSTALLATION/INTERCONNECTION, AND COMMISSIONING

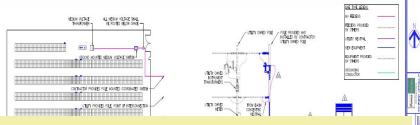
VOLUME III: OPERATIONS, MAINTENANCE, AND MONITORING

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nreca.coop/SUNDA

sunda@nreca.coop



Reference Designs 0.25 MW-AC 0.5 MW-AC 1.0 MW-AC

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www.nreca.coop/SUNDA

SUNDA Tools





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3.00%

Cost & Finance Screening Enter your inputs and ZIP code



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back Structure ost of Energy (\$/MWh) Community Solar Project: Cost per 305W Panel (prepay) Cost per 10W of Panel (lease)

Tax-Equity Flip Structure Levelized Cost of Energy (\$/MWh)

Community Solar Project:

st of Energy (\$/MWh)

0W of Panel (lease)

ost of Energy (\$/MWh)

0W of Panel (lease)

Solar Project: 05W Panel (prepay)

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Solar Project: 05W Panel (prepay)



535.73 \$ \$ 17.56

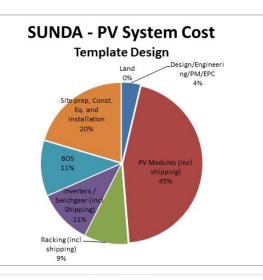
PPA Comparison

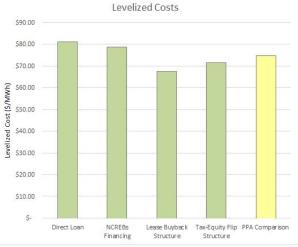
Levelized Cost of Energy (\$/MWh) First Year Cost/MWh Yearly Escalation

Cost per 305W Panel (prepay)

Cost per 10W of Panel (lease)







www.nreca.coop/SUNDA

Co-op Surveys on Solar

Solar Utility Network Deployment Acceleration (SUNDA):
2014 Survey Results
INITIATION AND GOALS OF THE SUNDA PROJECT
In Order 2013 the U.S. Department of Lenge (DC) and the National Bank Exercise Concentration Monotonia Monotonia and a comparitive generation an analist start 2.1 MM value instabilities research predict accentration generation of advancing bankers in phonohesisk. (VM) department or expensions. Descy bits Surdices bioletisms, OCD provided 331 embilities methods by 81.2 million rest starts from NIDO, for the National Rest UBM concentration France Organisms (PC). Ladoested Bank Tabletism Rest UBM concentration France Organisms (PC), Ladoested Bank Tabletism Rest UBM concentration France Organisms.
Unit new cooperatives each started from scratch in deploying allity scale solar PL Through this project, the participating on up are exploring two standardiaties can help bring them for "all" cancel tables procurrence, tapply chain and other scale of IV statistisms and also induce uncertainty about the effects of home initializations are appendix.
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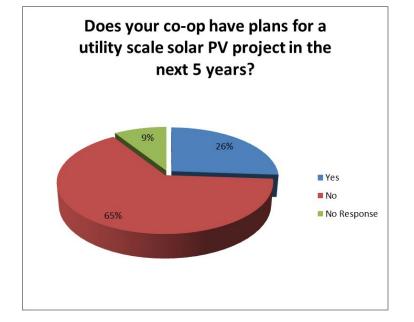


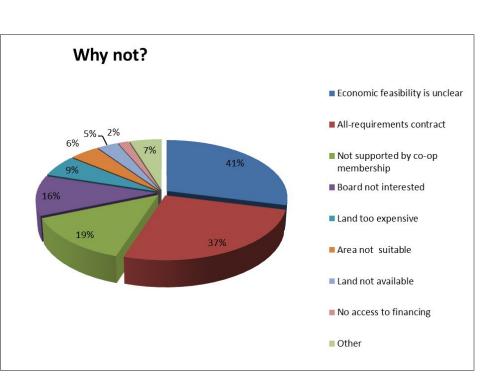


SUNDA PV Maturity Survey

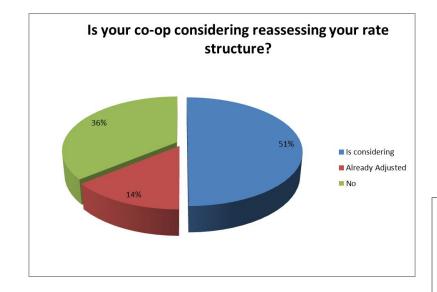
- Initial May 2014 survey identified 584 co-operatives that have or are planning solar
- Detailed June 2014 Survey with 174 respondents looked at in- depth issues regarding solar
- Survey will be repeated in 2017
- Co-op Community Solar Survey
 - Performed by Dean Moretton (Adaptive Microgrids) in 2015
 - Covered 119 co-ops who had already deployed solar
- Ongoing Internal Data Collection
 - Interactive site with internal data
 - List of "interested co-operatives" for SUNDA project has grown to 60.
 - Spring/Summer solar webinars drew 243 distribution co-ops (30%) and 50% of G&T co-ops (50%).

SUNDA PV Maturity Survey – Co-op Plans

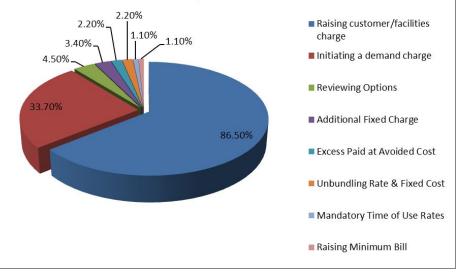




SUNDA PV Maturity Survey – Rate Structures

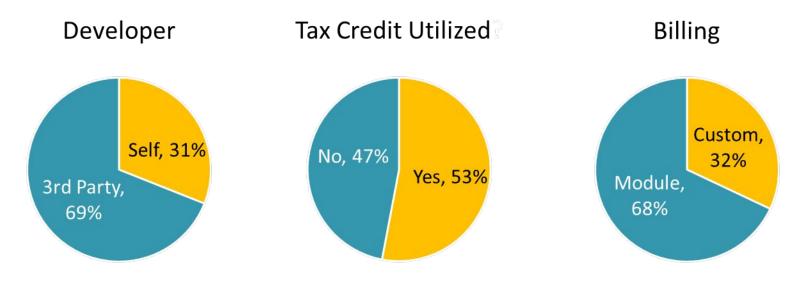


If considering adjustments, what options are being considered?



Co-op Market Survey

- Performed by Dean Moretton (Adaptive Microgrids)119
 Coops Deployed Solar
 - 76 Community Solar
 - 43 Solar Demonstration
 - 2014 Community deployments averaged \$3.29/Wp



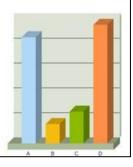
Informal Poll on Community Solar Webinar

• Webinar on 13 August 2015 had 500 participants. We did a couple of informal polls.

Is your co-op interested in deploying a PV system by 2016? If so, how big?	y Dei	c. 3	1,		
39 A 10-250kWac 17 B 250-500kWac 24 C 1-2MWac 17 D 2MW+ 83 E No immediate plans			1		
	A	В	с	D	E

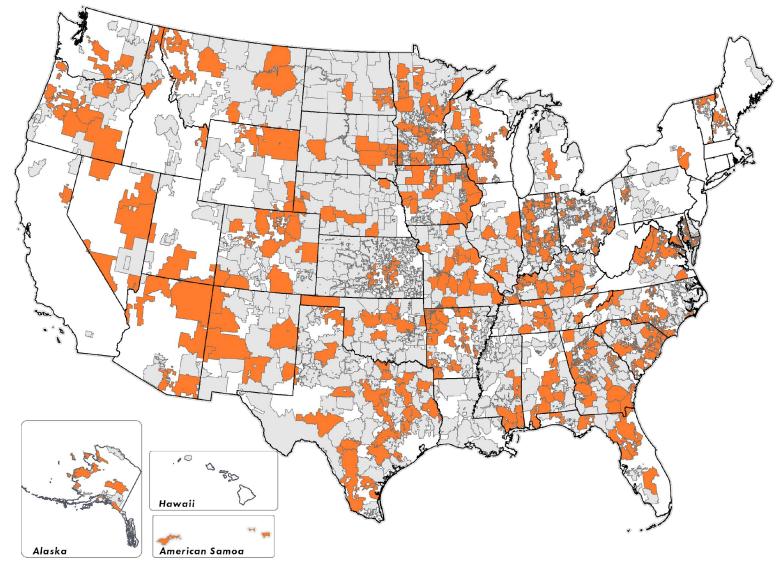
What is the biggest barrier to your co-op deploying a PV system, or an additional PV system?

- 77 A Cost: Understanding the economics of a PV program
- 14 B Land: Citing and permitting uncertainty
- 23 C Existing Contracts
- ⁸⁶ D Marketing Concerns: unsure of member interest or ability to sell subscriptions



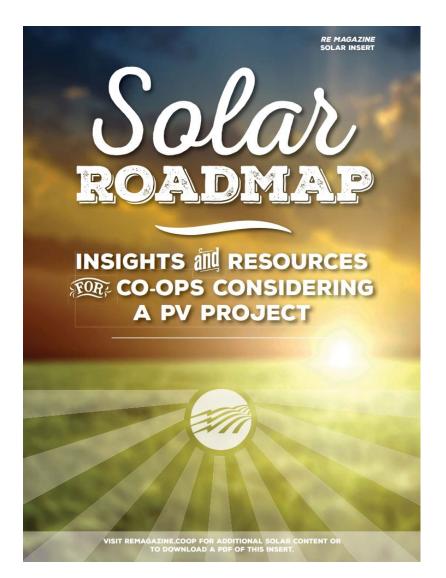
• We obviously still have work to do.

Co-op participation in Solar Webinars



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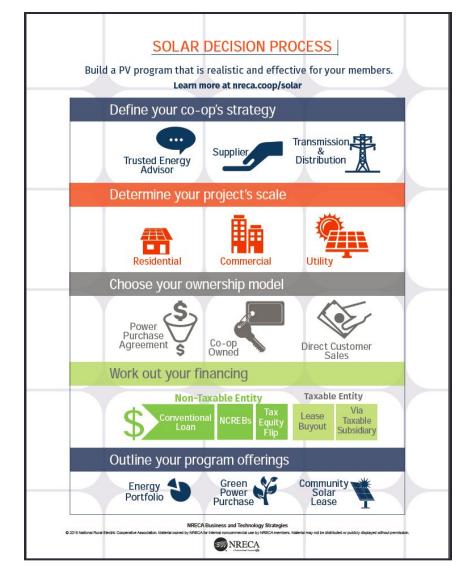
RE Magazine and Solar Insert



 August 2015 RE Magazine has a total of 31 articles, project snapshots and commentaries, including the special solar insert.

Of these 31 pieces, 13 (> 40%) are about solar.

Executive Decision Guide

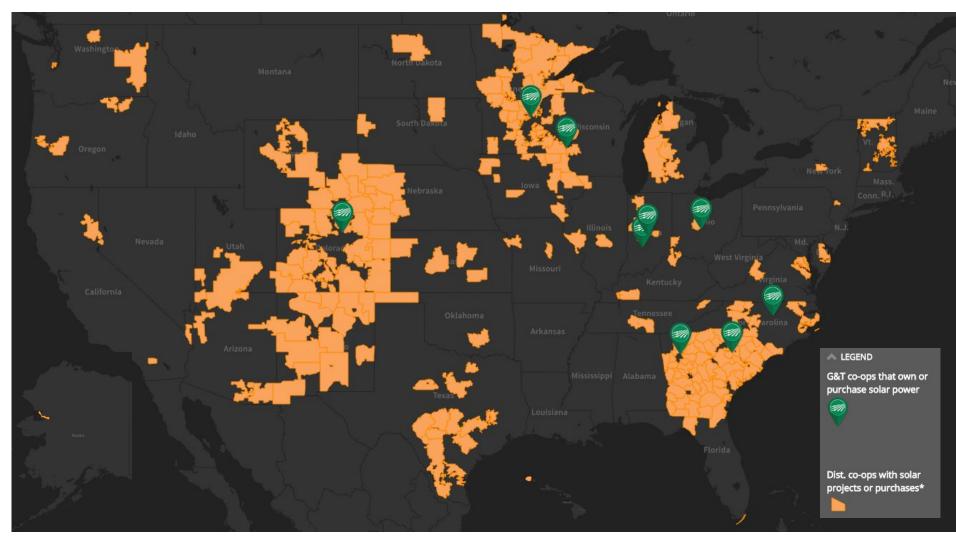


 Developing tools to help co-ops make decisions regarding solar at different levels:

- Board Strategy
- Executive Planning
- Business structure

Tracking Solar at Co-ops

http://www.nreca.coop/wp-content/plugins/nreca-interactive-maps/esri-solar-story-map/ind ex.html



The Cliff

- The 30% Commercial Investment Tax Credit is set to fall to 10% on Dec 30th, 2016. System must be installed and operating.
- Everyone is trying to put in projects to beat the deadline.
- Modules may sell out as early as December 2015.
- Inverters will also be in tight supply, as will design engineers and qualified EPCs.
- This situation may change, but assuming that is a big risk.
- It will take a couple of years to get

What about storage – is it real?

How consumers and utilities view the future

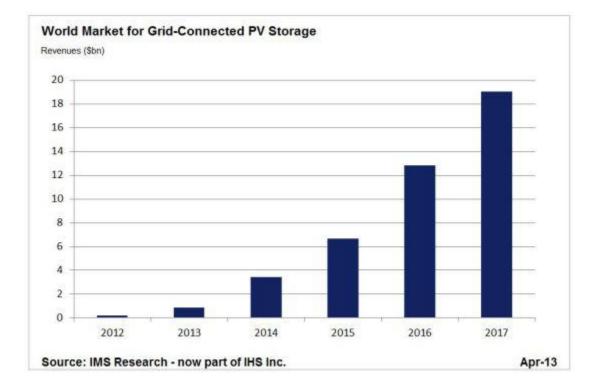
Electric co-ops and solar

Energy Storage

Open Modeling Framework

The future

Energy Storage – The next big thing?



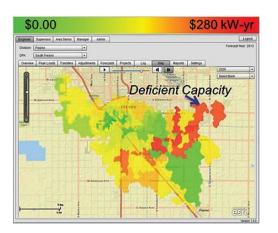
 The energy storage market is expected to grow rapidly, led by California, New York and International Markets

Energy Storage Applications

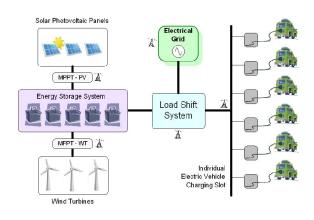
• Behind the Meter



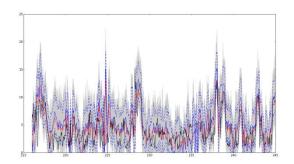
T&D Deferral



 Renewable Integration / Micro Grids



 Grid Stability / Frequency Response





Storage Technologies

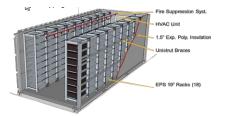
- Lithium
 - Short / medium durations
 - Medium / High cycle life
 - High RT efficiency
 - Mature technology, yet new innovations
 - Large systems require MANY small batteries
- Advanced Lead Acid
 - Medium / long durations
 - Medium cycle life
 - Moderate RT efficiency
 - Based on mature manufacturing technology
 - Cycling much improved
 - Potential low cost option













Storage Technologies (continued)

- Zinc Flow Batteries
 - Medium / long durations
 - High cycle life
 - Medium RT efficiency
 - Rapidly Developing technology and systems integration
- Vanadium Redox Flow Batteries
 - Medium / long durations
 - High cycle life
 - Medium RT efficiency
 - Advanced Electrolytes have improved longevity











Advanced Batteries

- Sodium Sulphur
 - Good cycle life
 - Large capacities
 - Mature technology
 - NGK is Market leader
- Sodium Nickel Chloride
 - High temperature, but long cycle life
 - Could be good for high-use applications
- Aqueous Ion
 - Designed for longer durations
 - Good cycle life
 - Early production stage
- Liquid Metal Batteries
 - Novel idea no moving parts
 - Could be extremely low cost option
 - New technology, first field demos soon







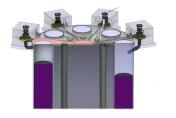
Ambri System 2 MWh, 10 Cores

Non-Battery Storage Technologies

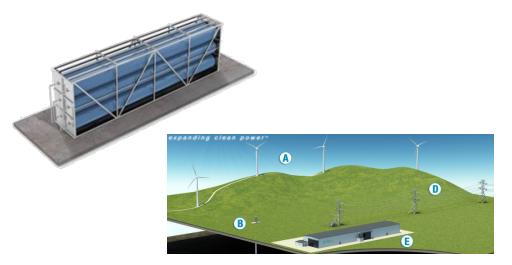
- Compressed Air
 - Compressed air energy storage
 - Unlimited cycle life
 - Large scale technology
 - Underground or above ground storage
- Everything else...
 - From pumped hydro and railcars filled with rocks to advanced heat pumps and cigarette butts







Scientists believe the secret to energy storage may be in a cigarette butt



Thermal Storage

- Hot Water Heater Storage
 - Used by co-ops
 - Low cost storage of excess renewables
 - Test projects to integrate into grid markets
- Ice Storage
 - Make ice at night, run cooling through during the day
 - Low cost solution to many issues



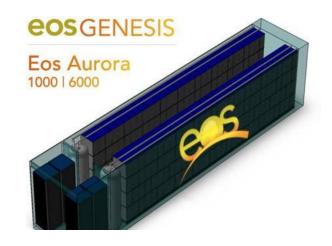


Oh, and I almost forgot flywheels and Zinc Air

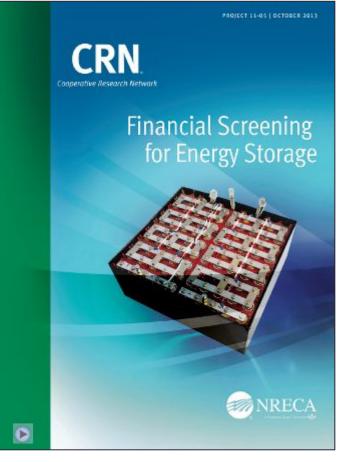
- Flywheels
 - Short Time Duration
 - Unlimited cycle life
 - Large scale technology
 - Mature technology with some new development
 - Used for frequency response and PV ramp mitigation
- Zinc Air
 - Low Cost
 - High Density
 - Long Cycle Life
 - High Efficiency
 - "Coming Soon"



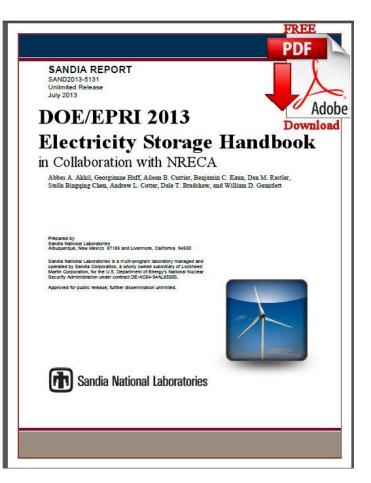




Resources



 NRECA Energy Storage Toolkit and DG Toolkit



 DOE / EPRI Energy Storage Handbook in collaboration with NRECA

What do I do about it?

 Get educated
 Co-ops have been invited to attend *Energy Storage North America* Conference in San Diego Oct 13-15th with free admission.

•Study the NRECA Energy Storage Toolkit •and start developing business cases for storage.

•Team together

 to look for pilot business cases, applications and demo project opportunities – get field experience to share with the co-op community.

Topics

How consumers and utilities view the future

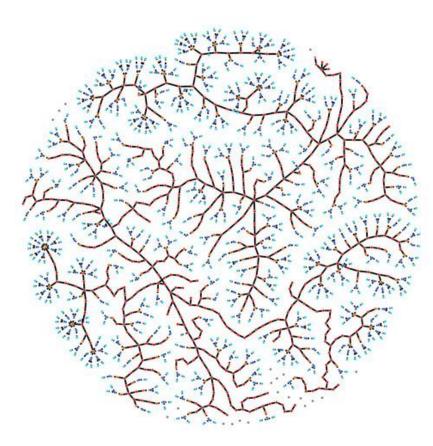
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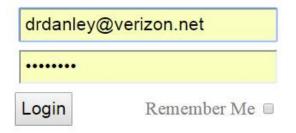
The future

Open Modeling Framework



rightarrow Documentation rightarrow Discussion fightarrow Development

Open Modeling Framework



Forgot Password?

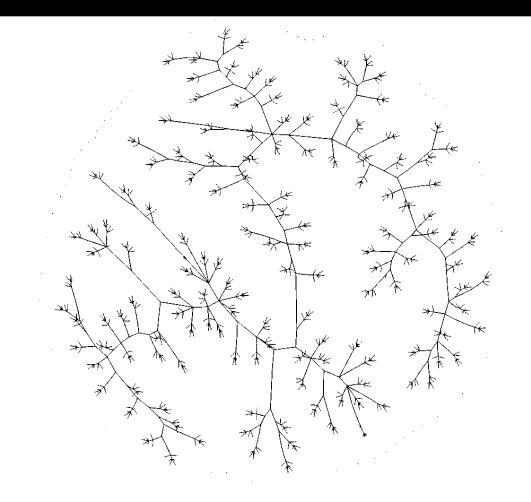
Want Guest Access?

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drdanley@verizon.	energyStorage pvWatts	test	solarFinancia
drdanley@verizon.	voltageDrop solarFinancial solarConsumer cvrStatic solarRates solarSunda solarEngineering	MW near ss	solarEngineer
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drdanley@verizon.		es test 4feb15 RERAN 2	solarRates
	gridlabMulti		
New model of type	energy Storage	Create Model	

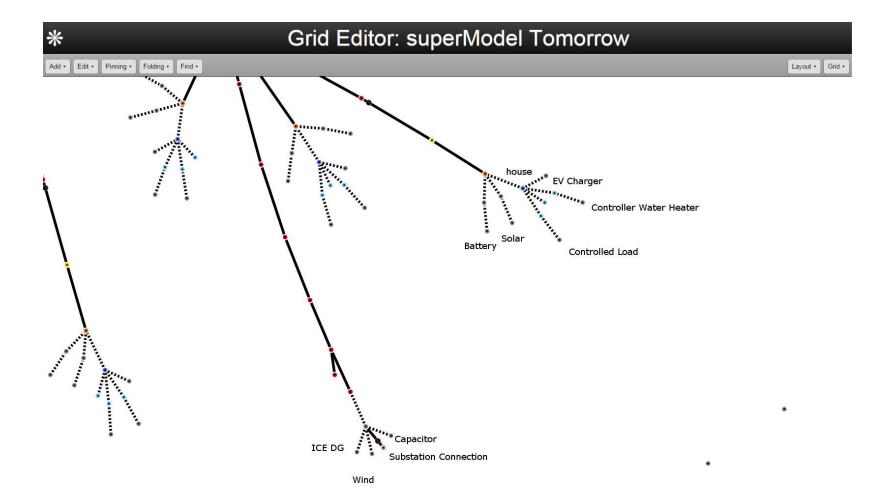
OMF Interactive Feeder Editor

Scenare

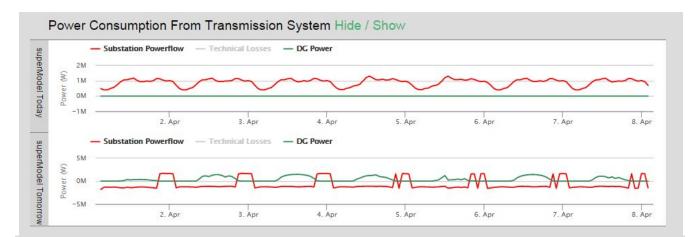
Grid Editor: superModel Tomorrow

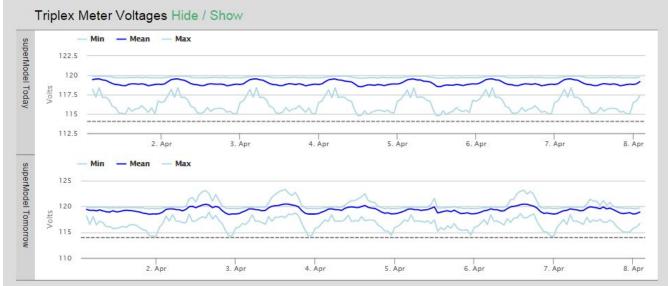


Feeder Detail with Solar + Storage



Results of GridLab-D Run





 Powerflow and meter voltage are among the results calculated

 Also performs economic analysis

Topics

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Essence: Dynamically Adapting, Reactive Cyber Security

•Eliminate Attackers

•Defend Perimeter

Harden Applications

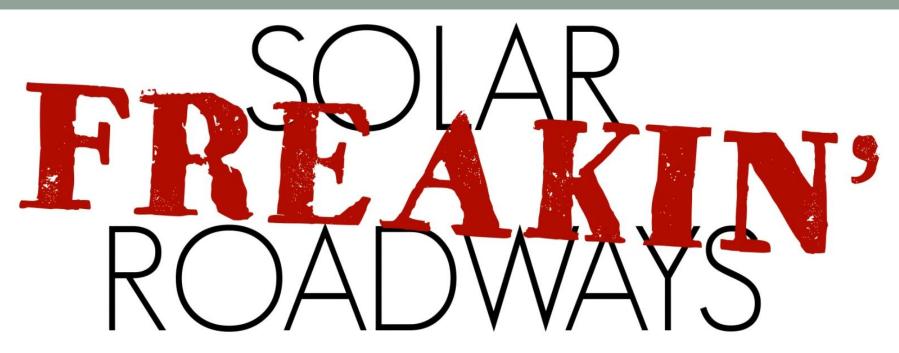
•Segment

•React •Quickly

The most important number in cyber security 204 days

 Full passive packet capture and auto / managed response with machine learning.

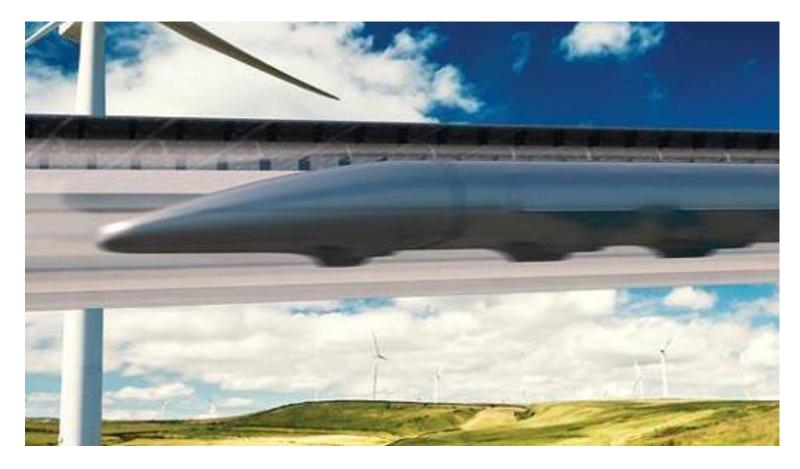
 $204 \rightarrow 1 = 99$ % reduction in cyber response time



- <u>http://www.youtube.com/watch?v=qITA3r</u> <u>npgzU</u>
- Good idea? Bad idea? Goofy Idea?
- Does it matter?
- SolarRoadways has used CrowdFunding to raise over \$1.7M since April 21st – exceeding their original \$1M goal. (If you donate \$40, you can get a "Solar Freakin' Roadways" hat!)



All Aboard ...



Rendering courtesy of Hyperloop Transportation Technologies

Thank You

Doug Danley

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