

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



**National Rural Electric
Cooperative Association**

A Touchstone Energy® Cooperative 

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

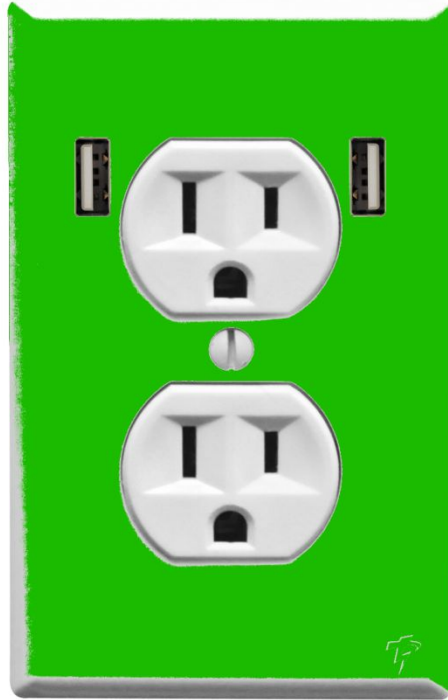
Electric co-ops and solar

Energy Storage

Open Modeling Framework

The future





HomeKit



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



A photograph of a train on a track, viewed from the front. The train's headlights are on, creating a bright glow. The track is surrounded by trees and foliage. The overall scene is somewhat hazy or misty. The text "Smart Meter pushback." is overlaid on the left side of the image.

Smart Meter
pushback.

Rate Reforms

A photograph of a train approaching on a track through a wooded area. The train's headlights are on, creating a bright glow. The scene is dimly lit, suggesting dusk or dawn. The trees are bare, and the overall atmosphere is somewhat somber and industrial.

Smart Meter
pushback.

Rate Reforms

EPA 111(d)
Regulated
Carbon
Emissions

Renewable
Portfolio
Standards



Smart Meter
pushback.

Rate Reforms

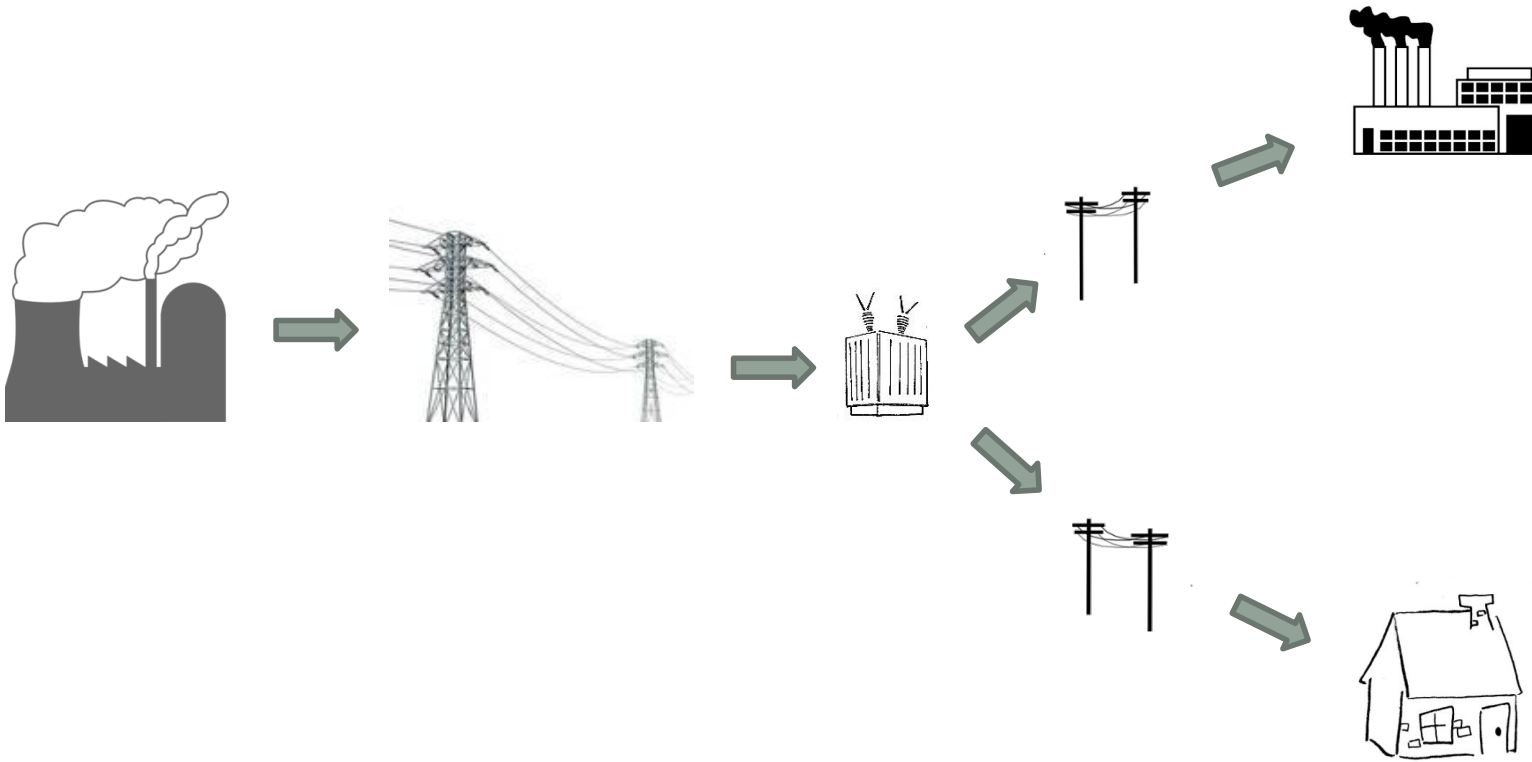
EPA 111(d)
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Carbon
Emissions

Renewable
Portfolio
Standards

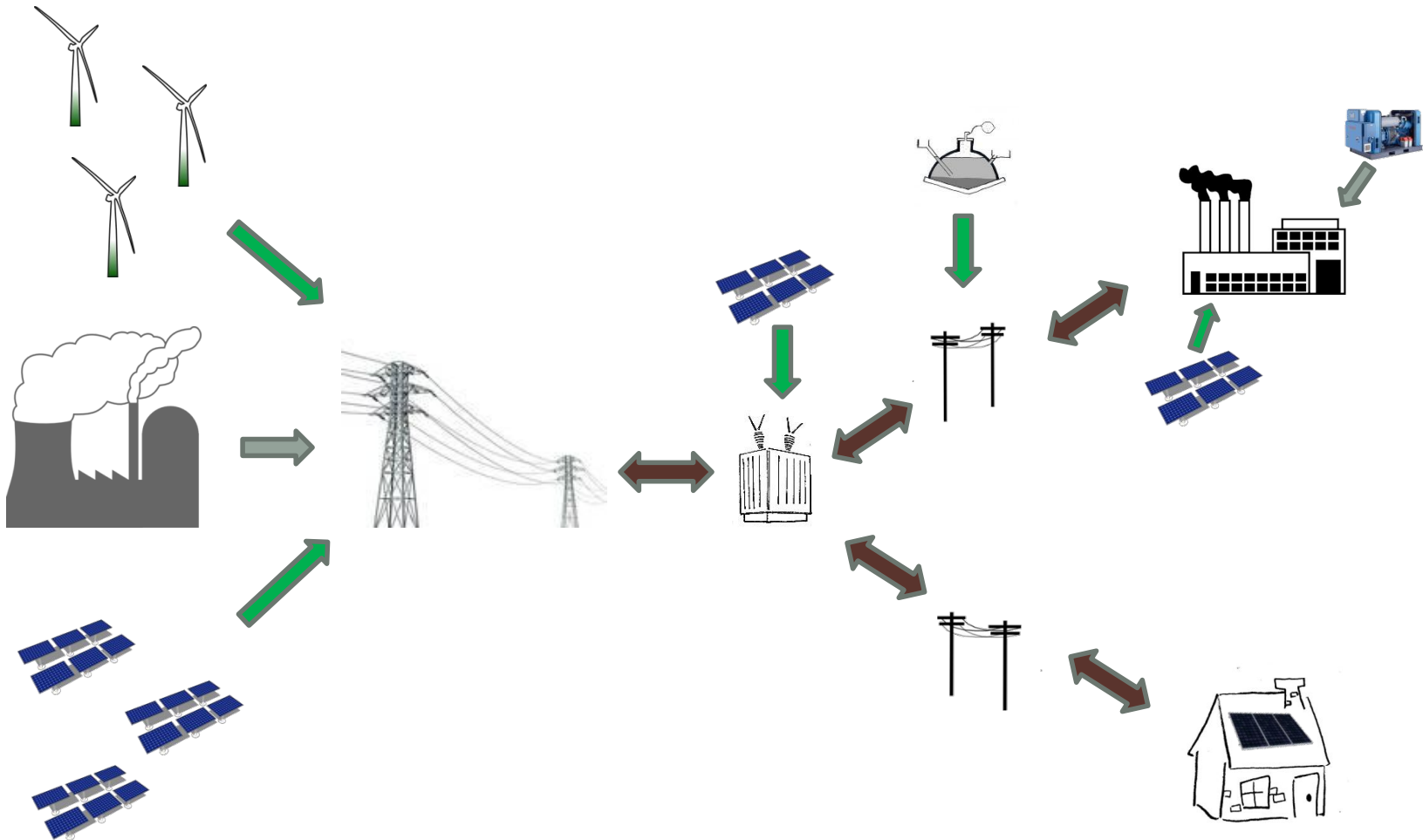
If a train is coming at you, closing your eyes won't save you ... but if you look right at it, you at least have a chance to jump.

- Andrew Vachss

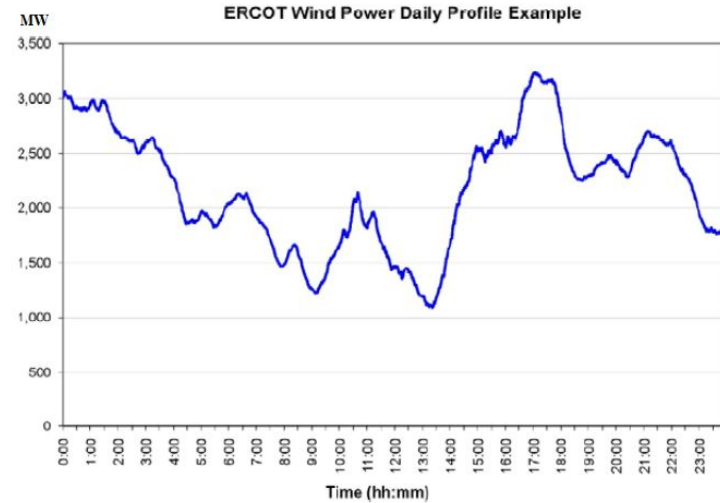
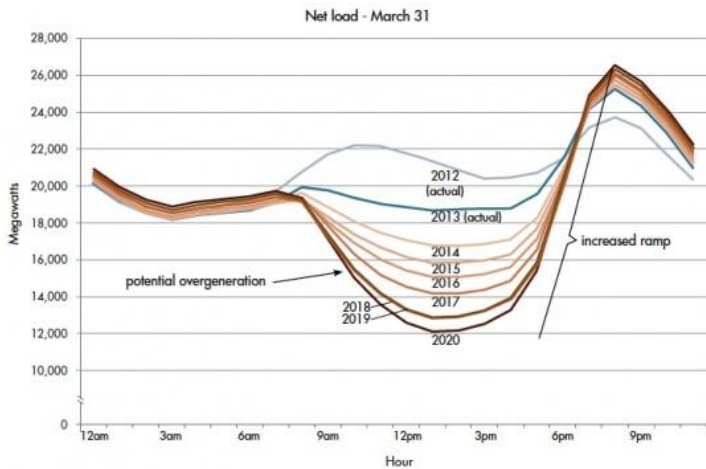
The Electric Grid: 1880-2000



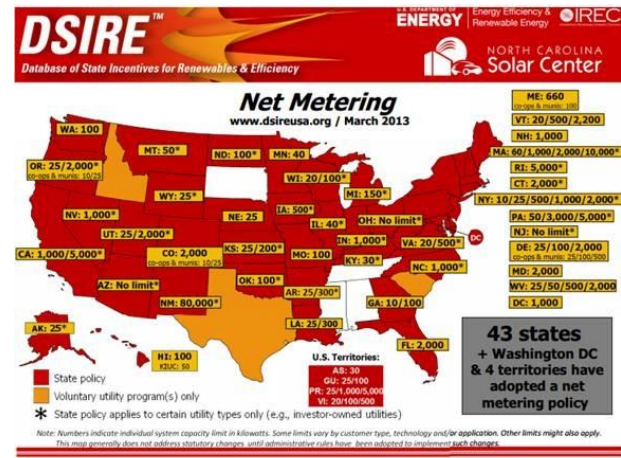
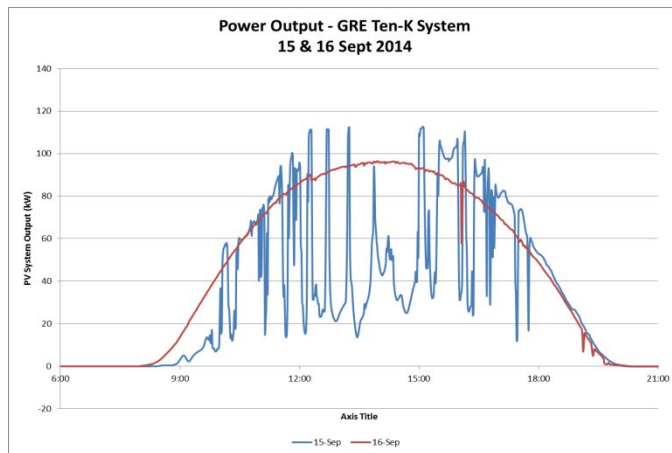
The Electric Grid: 2000-2015



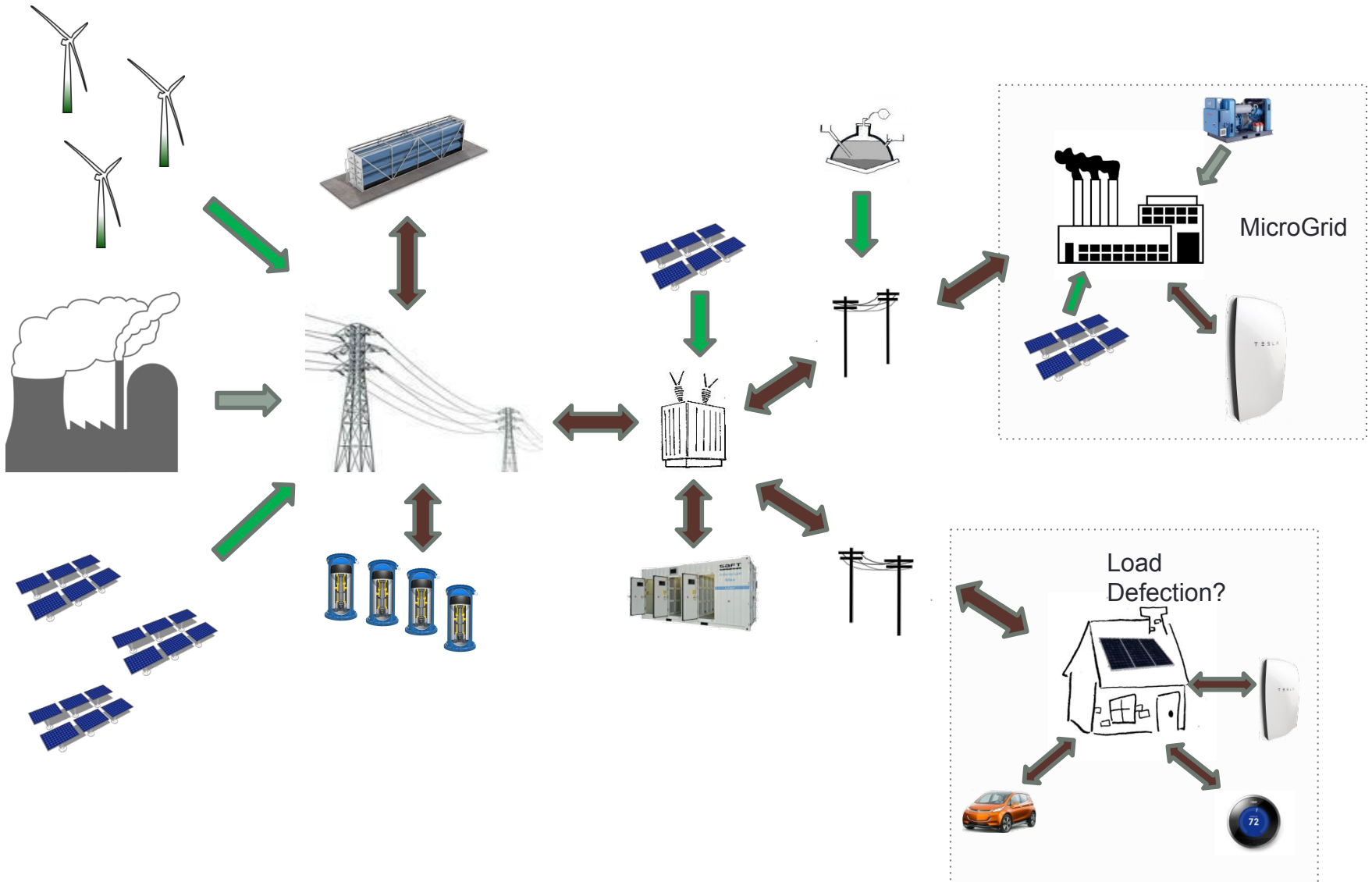
Issues with the Modern Grid



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



The Electric Grid: 2015- ??



Back to the main topic ...

How consumers and utilities view the future

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Co-op Solar in the News

Eau Claire utility proposes community solar program

The #1 Solar Utility Is In

February 18th, 2014 by [John Farrell](#)

Electric cooperative announces solar project

Prairie Power, Inc., an electric generation and distribution cooperative headquartered in Springfield, has announced plans to build solar production facilities

Trabish | June 3, 2015 print

Community Solar

Tap into the power of the sun with Roanoke EC!

Electric Cooperatives of Arkansas To Sell Commercial-Grade Solar Power Units

op's \$85 million

Aerojet Rocketdyne, Arkansas Electric Cooperative Corporation and Ouachita Electric Solar

Santee Cooper and electric cooperatives to create solar farm "community solar"

handle electric project as first

Vermont Electric Co-op array

Vermont Electric Co-op aims to build state's largest utility-owned partnership

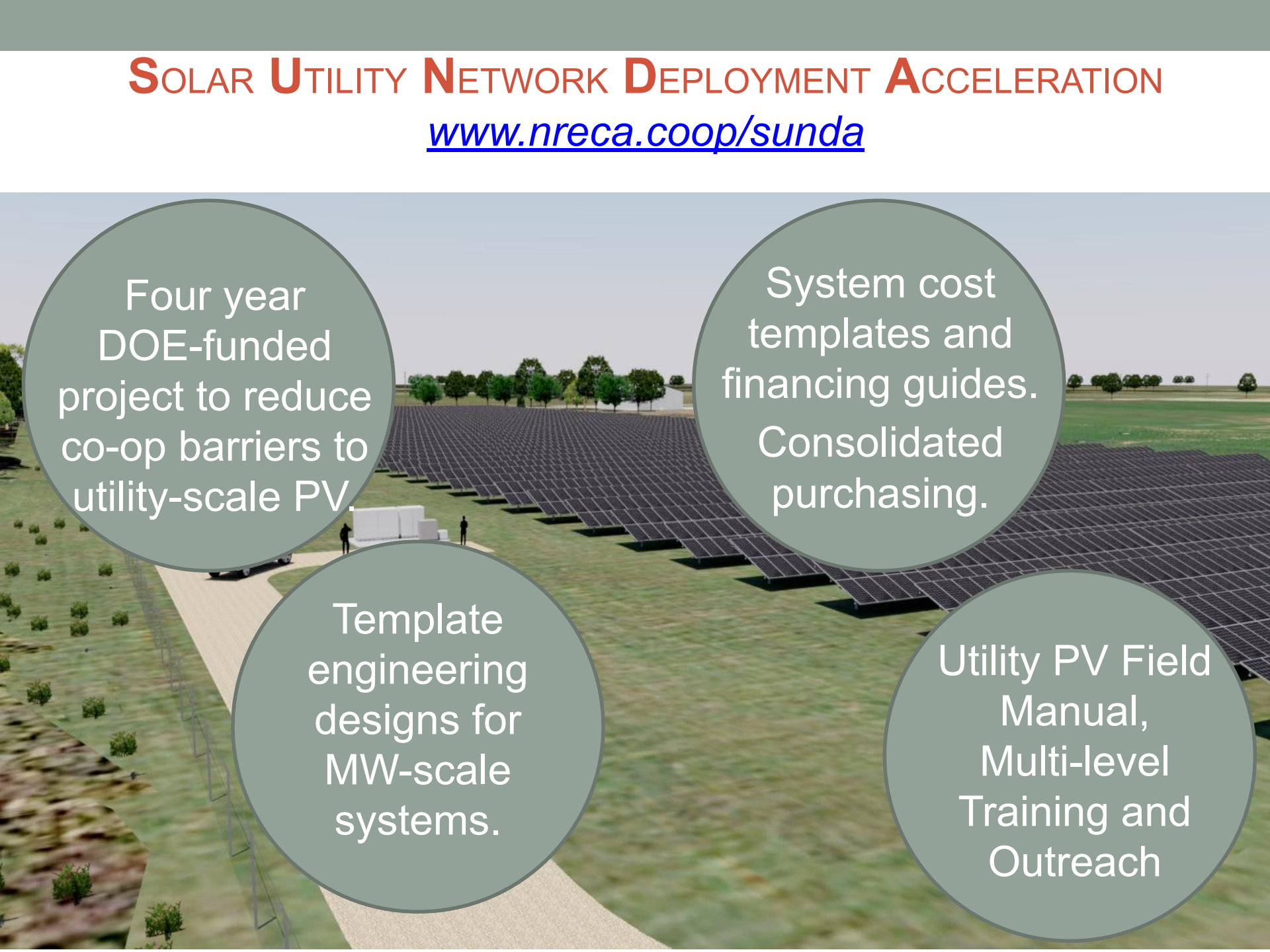
Ozarks Electric plans to build 1-megawatt solar power facility near Springdale

Community Jackson EMC participates in large solar power project in Cass County first in the state

able to serve customers want solar
New solar plant opens in the Tri-States

SOLAR UTILITY NETWORK DEPLOYMENT ACCELERATION

www.nreca.coop/sunda



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

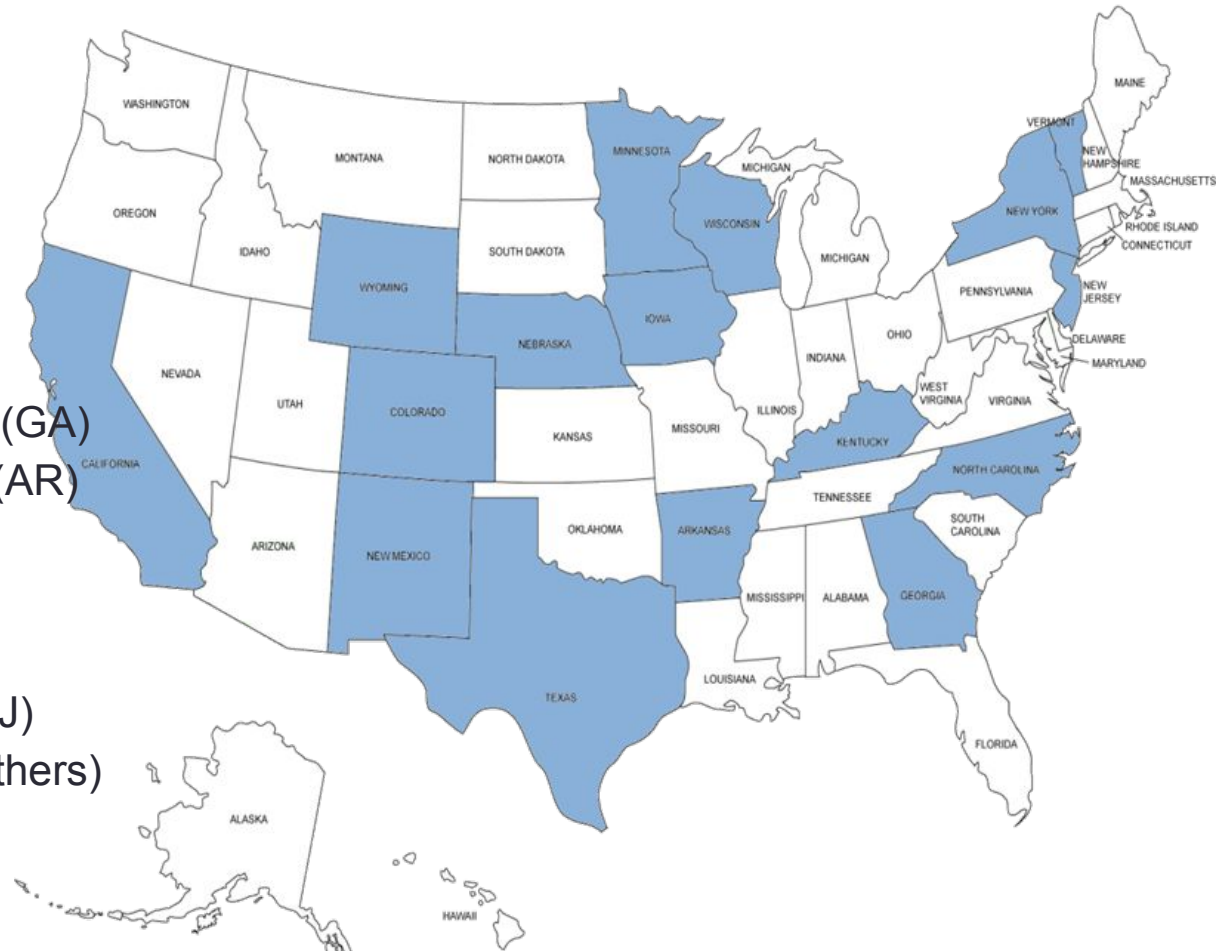
System cost
templates and
financing guides.
Consolidated
purchasing.

Template
engineering
designs for
MW-scale
systems.

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)



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 I: BUSINESS MODELS AND FINANCING OPTIONS

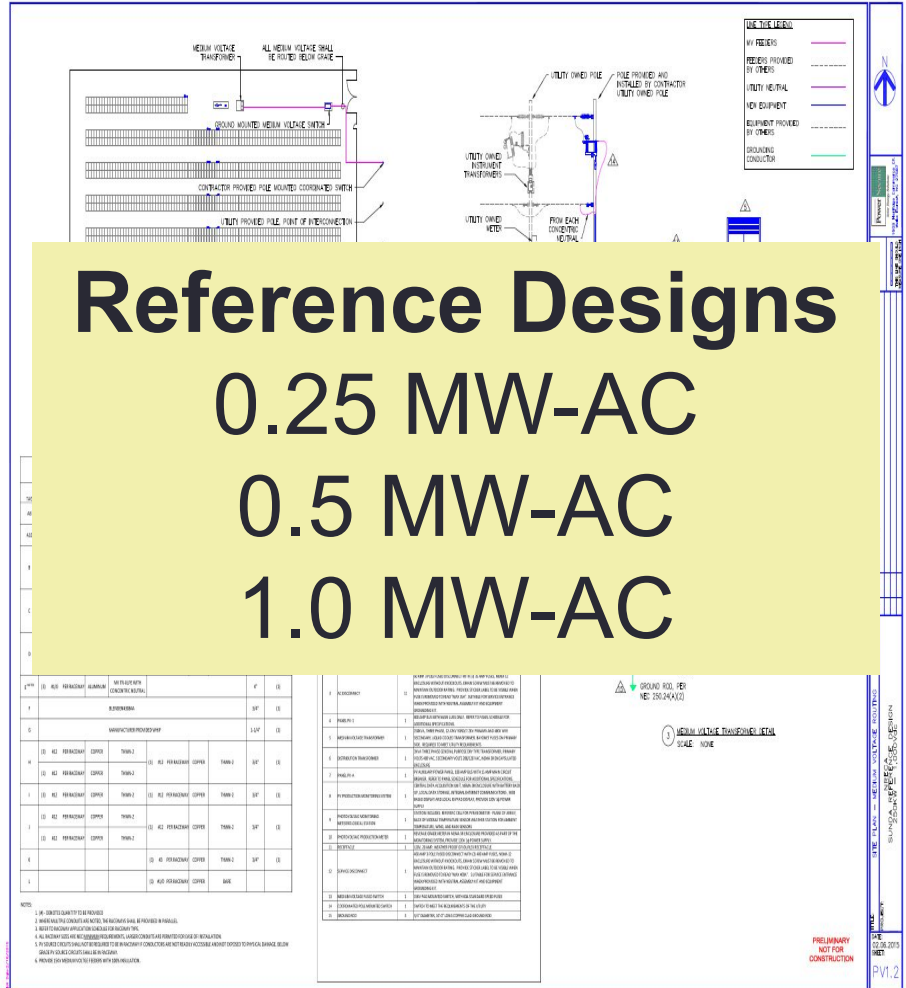
VOLUME II: PLANNING, DESIGN, INSTALLATION/INTERCONNECTION, AND COMMISSIONING

VOLUME III: OPERATIONS, MAINTENANCE, AND MONITORING

This work, authored by the National Rural Electric Cooperative Association, was funded in whole or in part by the Department of Energy under U.S. Government contract DE-EE-0006333. All copyright rights are reserved by the National Rural Electric Cooperative Association, the copyright owner.



nreca.coop/SUNDA
sunda@nreca.coop



www.nreca.coop/SUNDA

SUNDA Tools

SUMMARY RESULTS

XYZ, EC

Re-Calculate

Installed System Cost:
 \$/Wdc Installed:
 Capacity Factor:
 First Year System Output (MWh_{ac})

\$	2,275,221
\$	1.64
	17%
	2,020

Levelized Cost of Energy (\$/MWh)
 Solar Project:
 305W Panel (prepay)
 10W of Panel (lease)

\$	81.42
\$	608.73
\$	19.96

Financing

Levelized Cost of Energy (\$/MWh)
 Solar Project:
 305W Panel (prepay)
 10W of Panel (lease)

\$	78.84
\$	589.49
\$	19.33

Bank Structure

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

\$	67.69
\$	506.06
\$	16.59

Tax-Equity Flip Structure

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

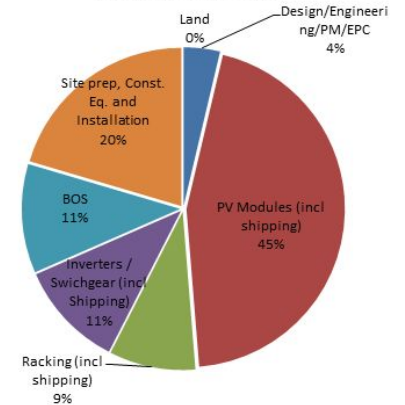
\$	71.65
\$	535.73
\$	17.56

PPA Comparison

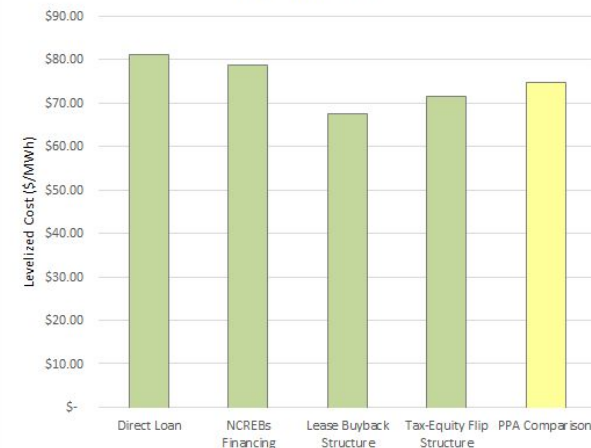
Levelized Cost of Energy (\$/MWh)
 First Year Cost/MWh
 Yearly Escalation

\$	74.94
\$	57.50
	3.00%

SUNDA - PV System Cost Template Design



Levelized Costs



Cost & Finance Screening
 Enter your inputs and ZIP code

www.nreca.coop/SUNDA



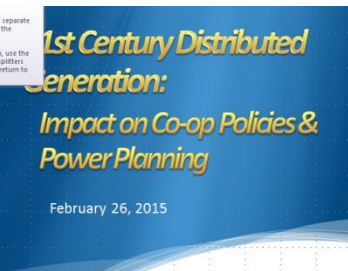
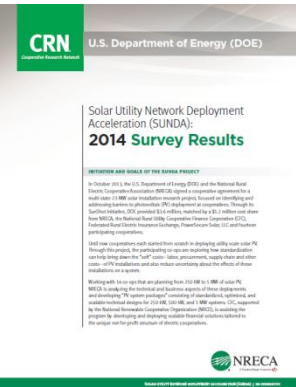
NRECA

A Touchstone Energy® Cooperative

Co-op Surveys on Solar

- 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

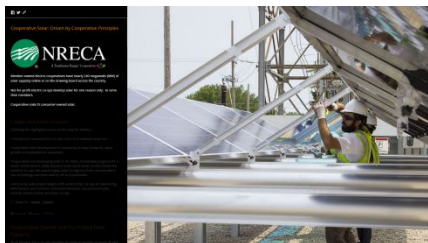


- Co-op Community Solar Survey

- Performed by Dean Moretton (Adaptive Microgrids) in 2015
- Covered 119 co-ops who had already deployed solar

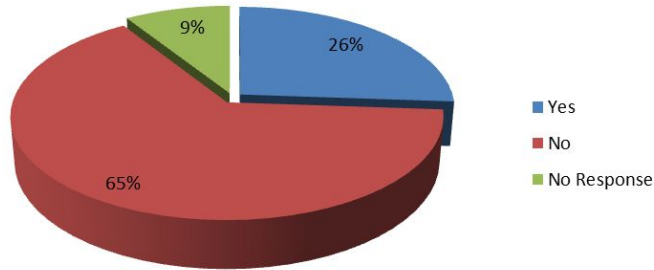
- Ongoing Internal Data Collection

- 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%).

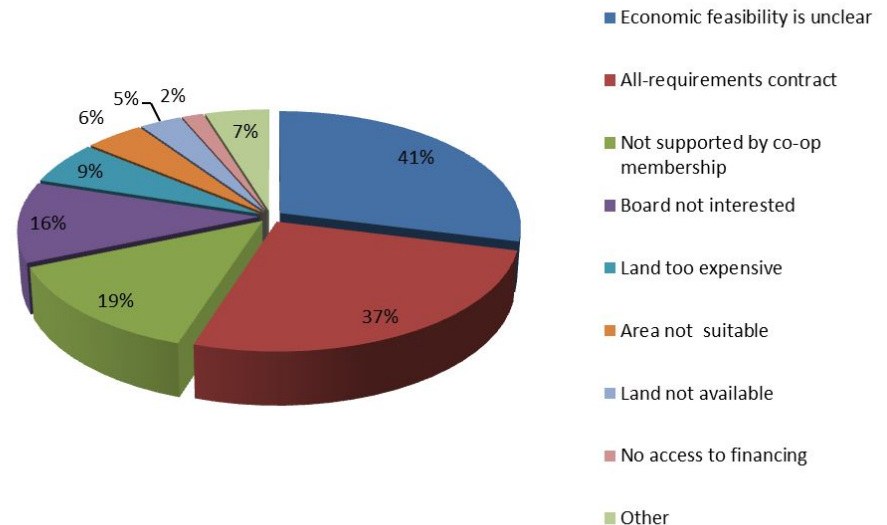


SUNDA PV Maturity Survey – Co-op Plans

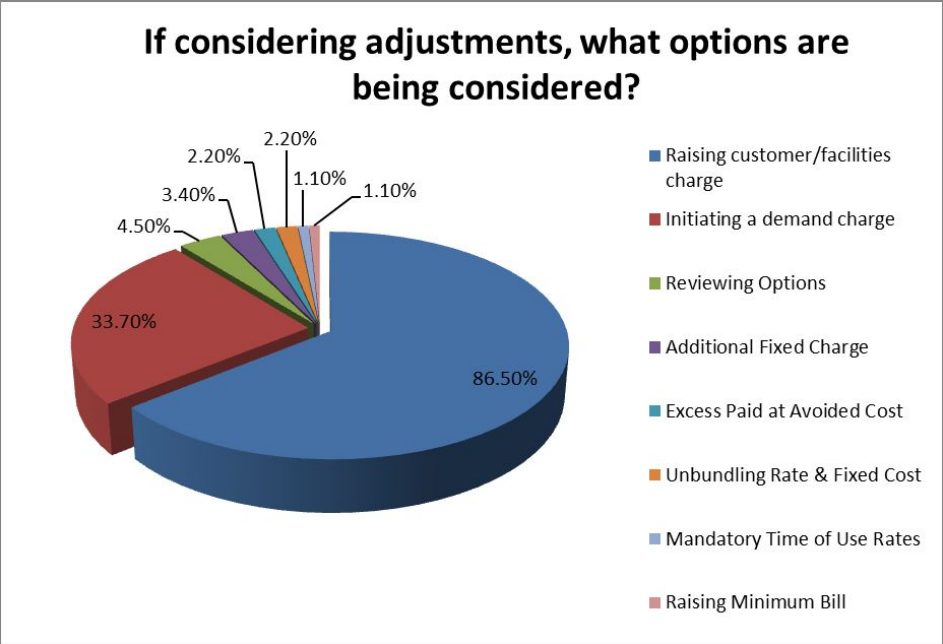
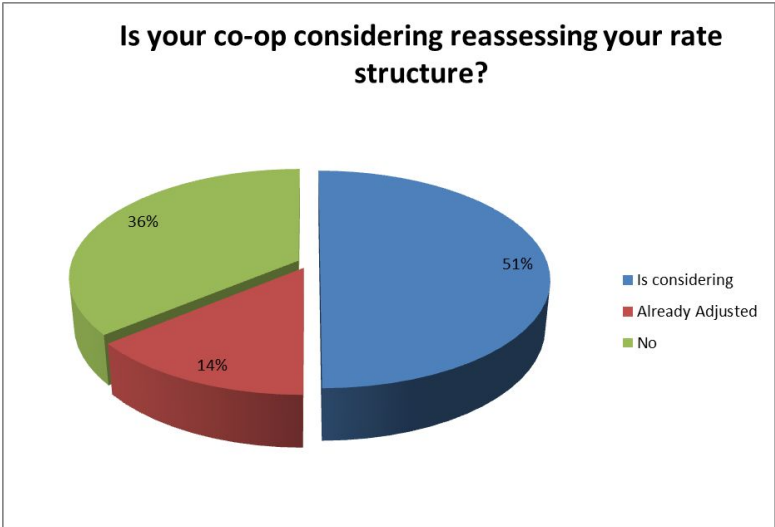
Does your co-op have plans for a utility scale solar PV project in the next 5 years?



Why not?



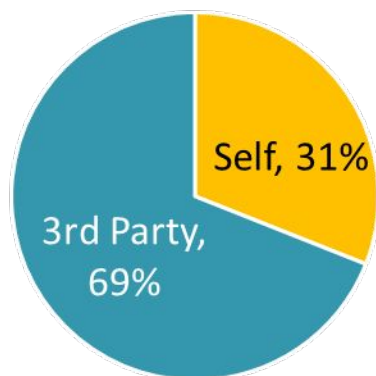
SUNDA PV Maturity Survey – Rate Structures



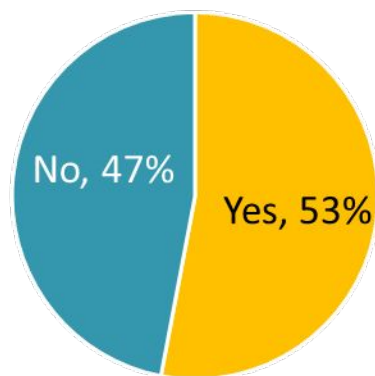
Co-op Market Survey

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

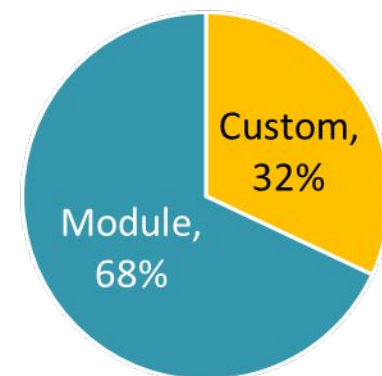
Developer



Tax Credit Utilized?

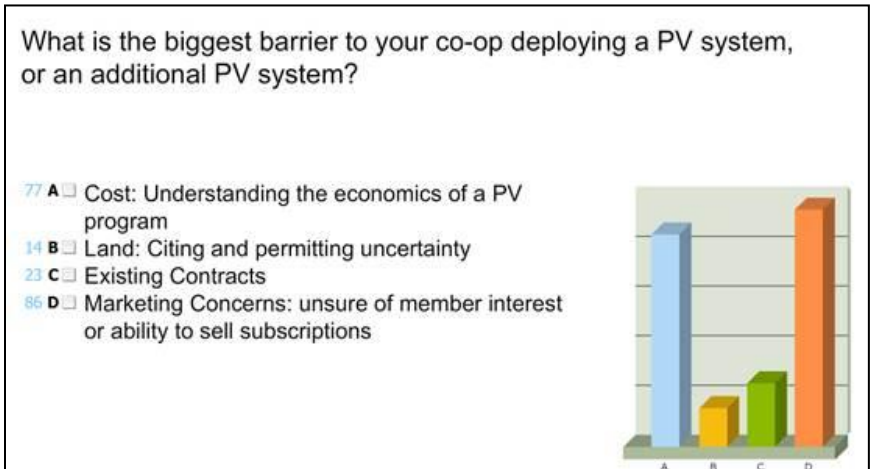
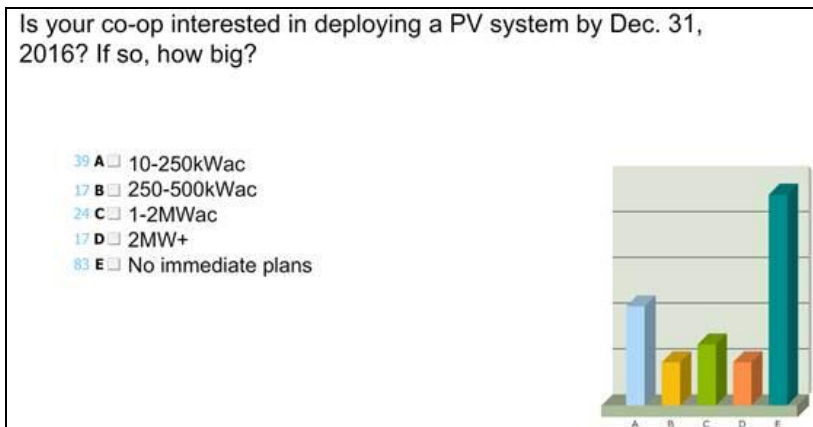


Billing



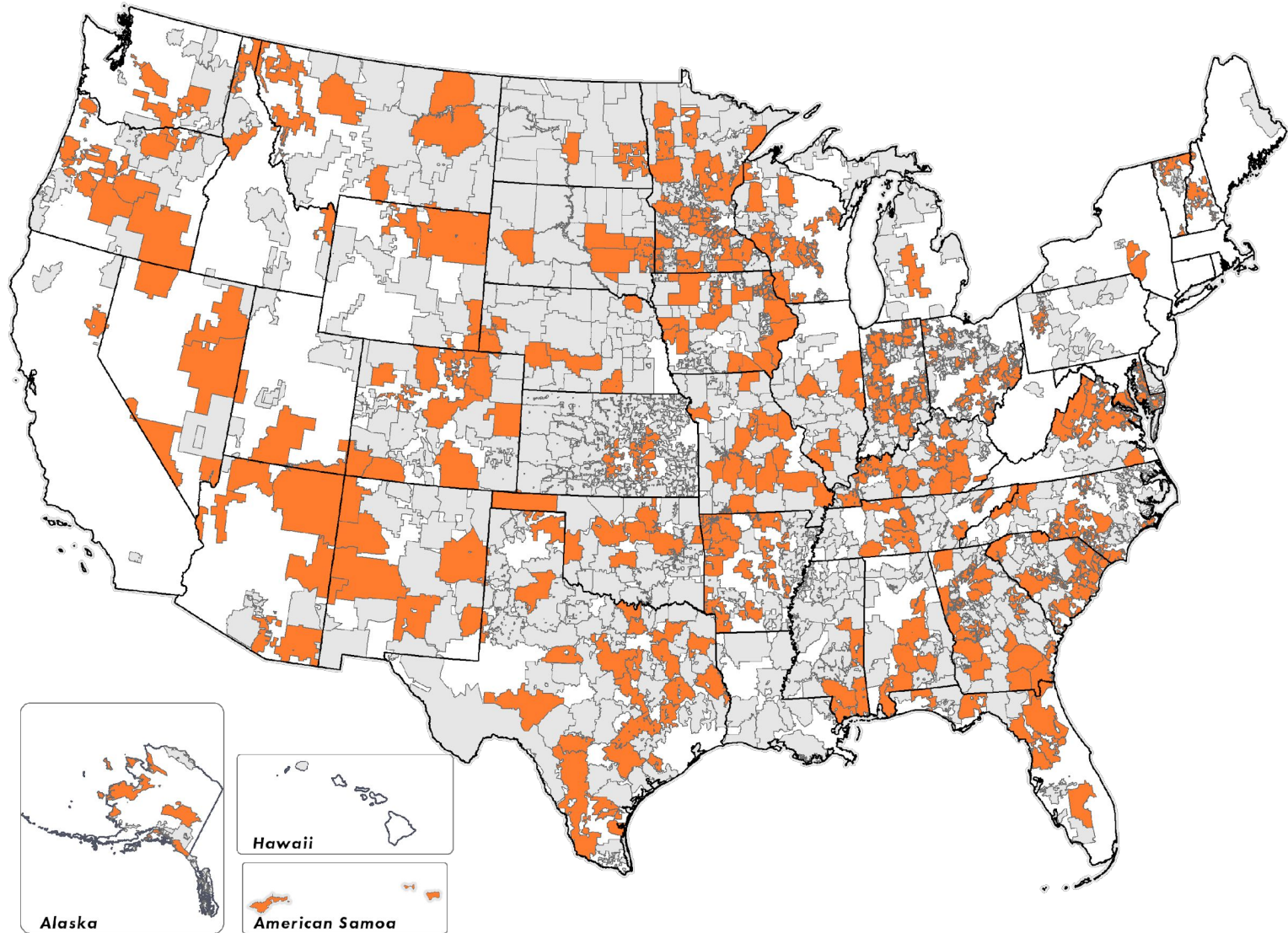
Informal Poll on Community Solar Webinar

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

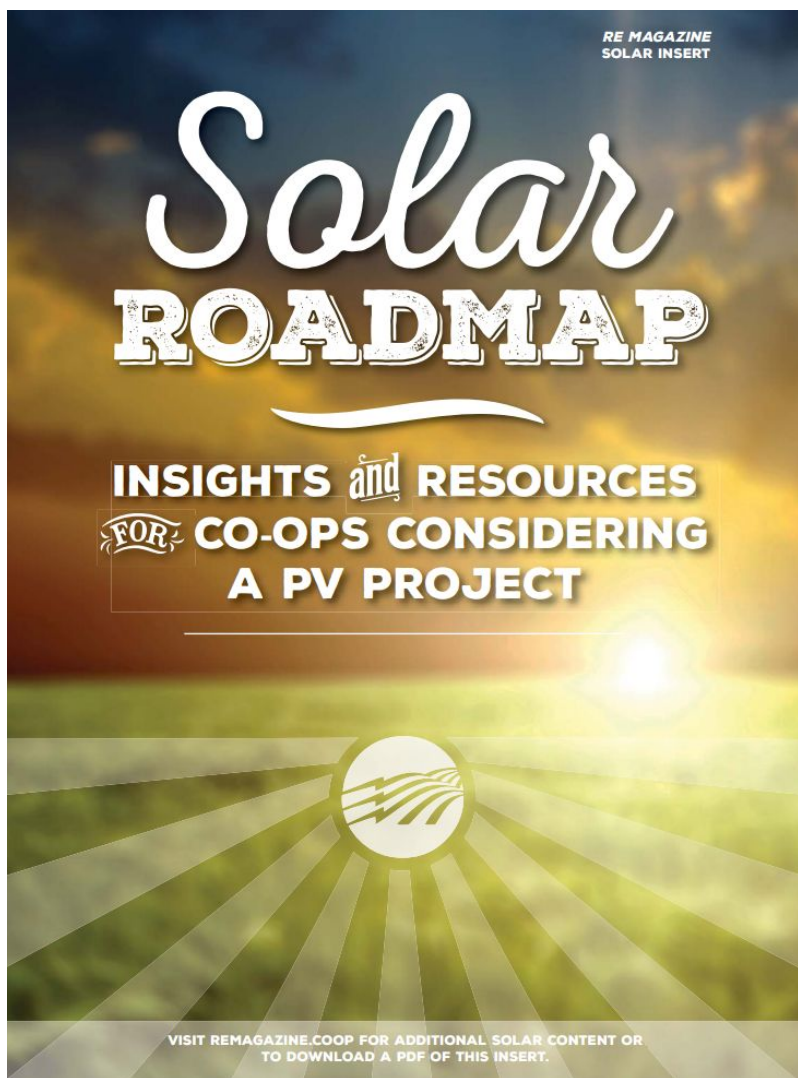


- We obviously still have work to do.

Co-op participation in Solar Webinars



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.

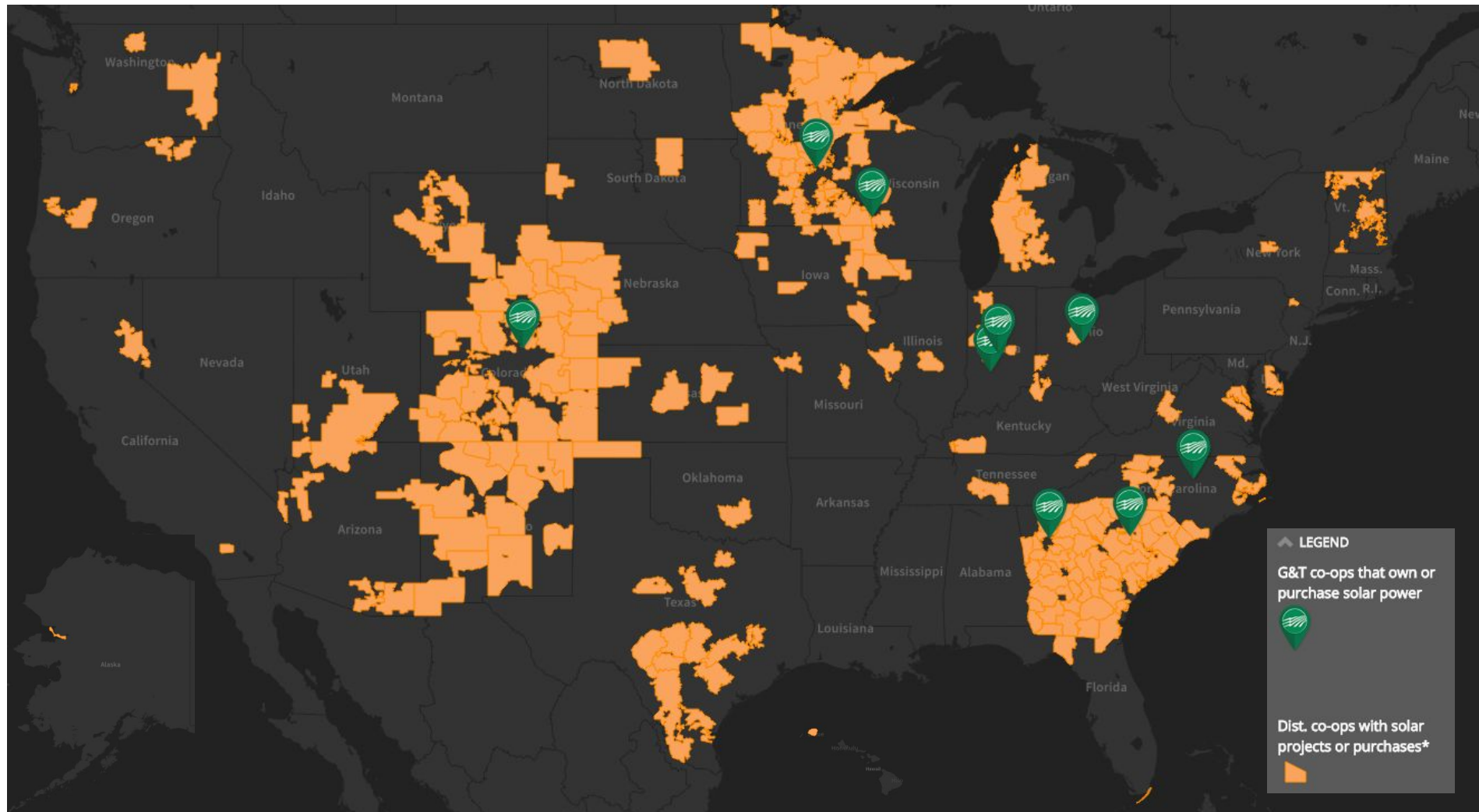
Executive Decision Guide



- 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/index.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

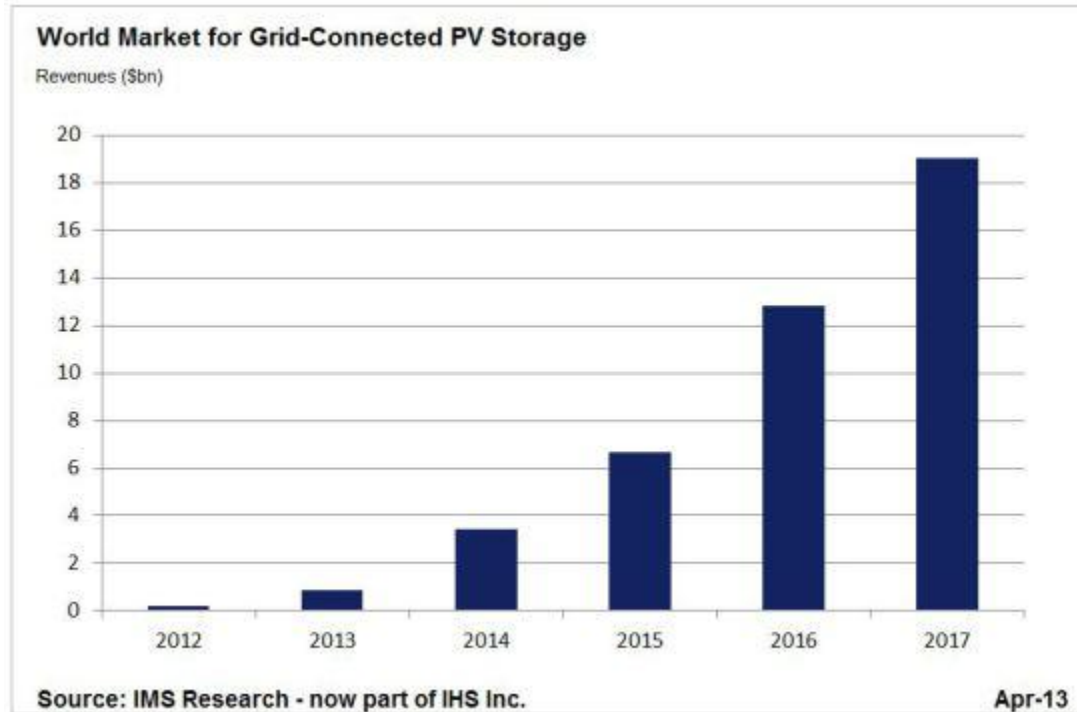
Electric co-ops and solar

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The future

Energy Storage – The next big thing?



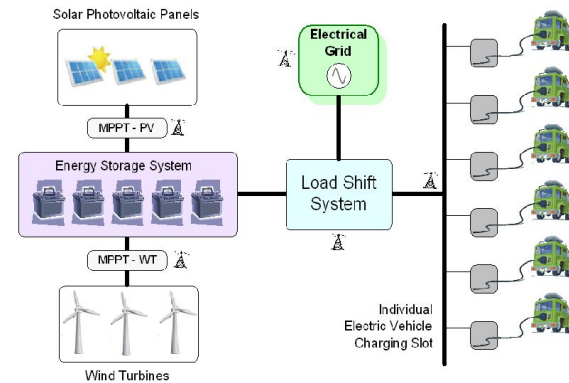
- The energy storage market is expected to grow rapidly, led by California, New York and International Markets

Energy Storage Applications

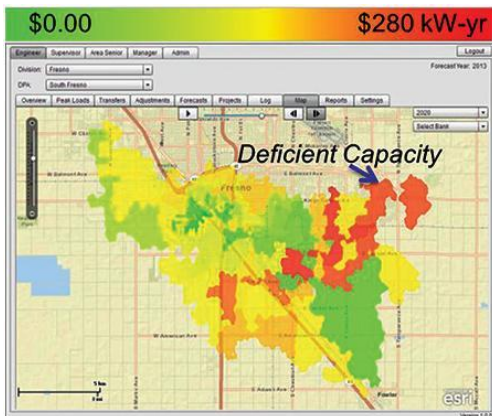
- Behind the Meter



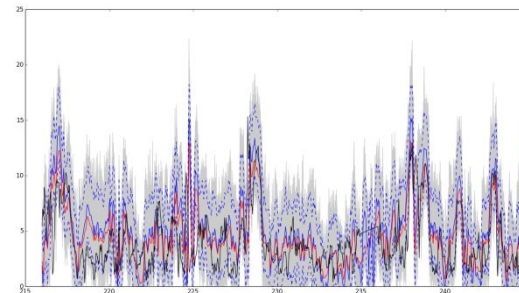
- Renewable Integration / Micro Grids



- T&D Deferral



- Grid Stability / Frequency Response

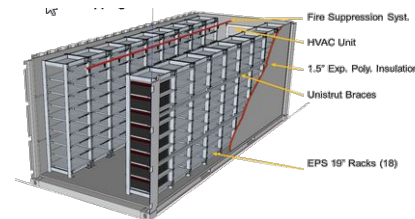


The Market is Getting (Over?)Crowded



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



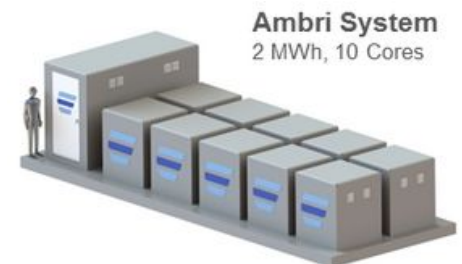
- Vanadium Redox Flow Batteries

- Medium / long durations
- High cycle life
- Medium RT efficiency
- Advanced Electrolytes have improved longevity



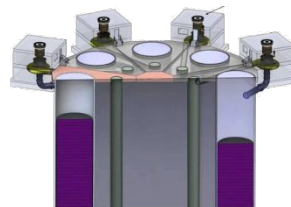
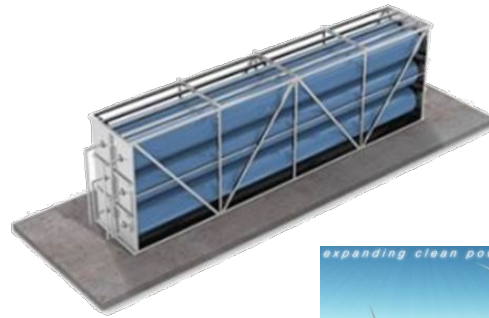
Advanced Batteries

- 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



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

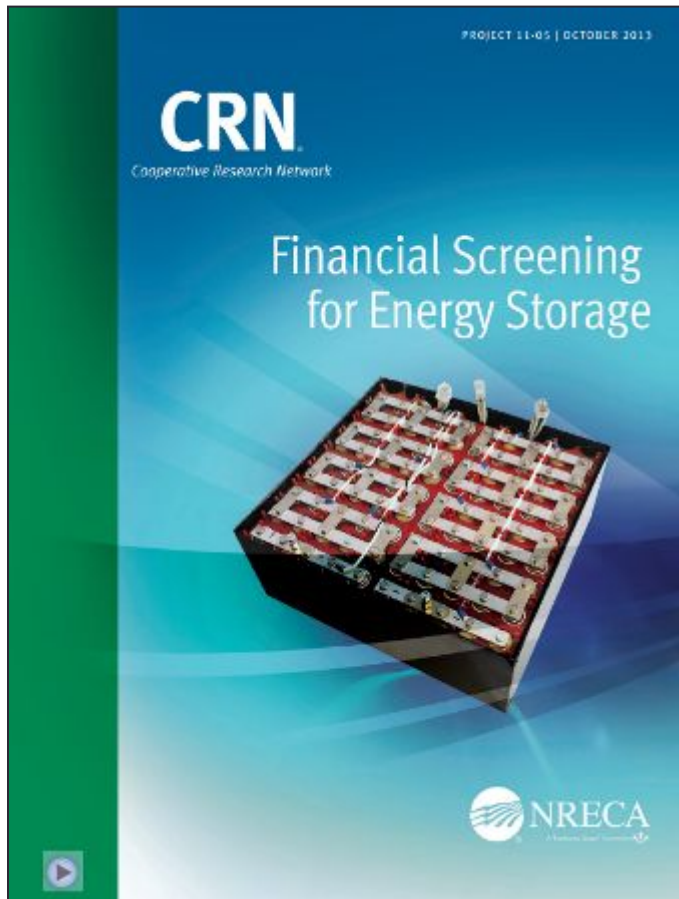
- Low Cost
- High Density
- Long Cycle Life
- High Efficiency
- “Coming Soon”

eosGENESIS

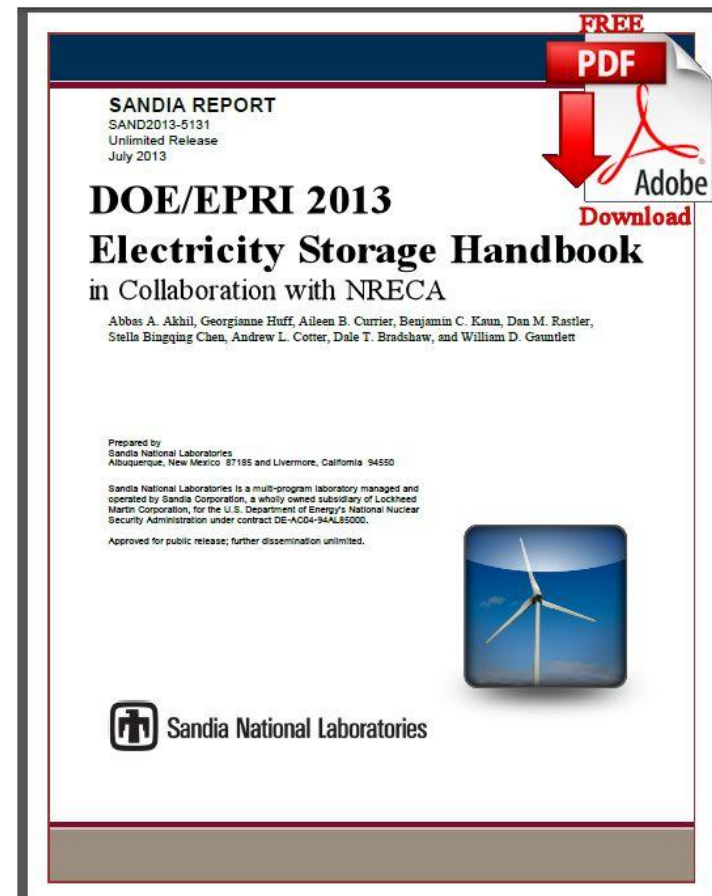
Eos Aurora
1000 | 6000



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

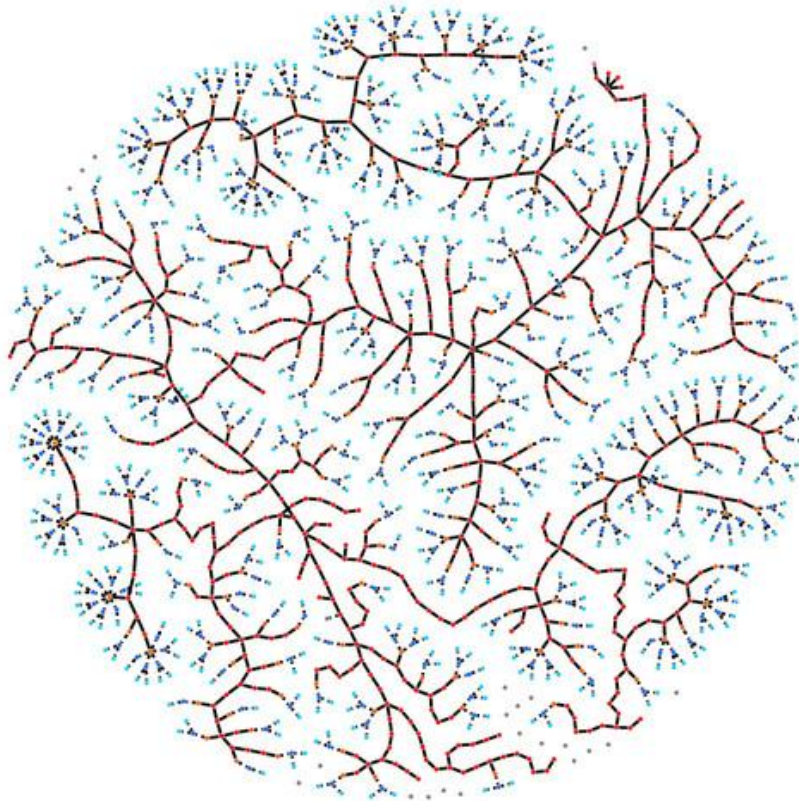
Electric co-ops and solar

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Open Modeling Framework

The future

Open Modeling Framework



Open Modeling Framework

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.....

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drdanley@verizon.	energyStorage	test
drdanley@verizon.	pvWatts	
drdanley@verizon.	voltageDrop	MW near ss
drdanley@verizon.	solarFinancial	
drdanley@verizon.	solarConsumer	
drdanley@verizon.	cvrStatic	ps test 4feb15 RERAN 2
drdanley@verizon.	solarRates	solarRates
	solarSunda	
	solarEngineering	
	gridlabMulti	

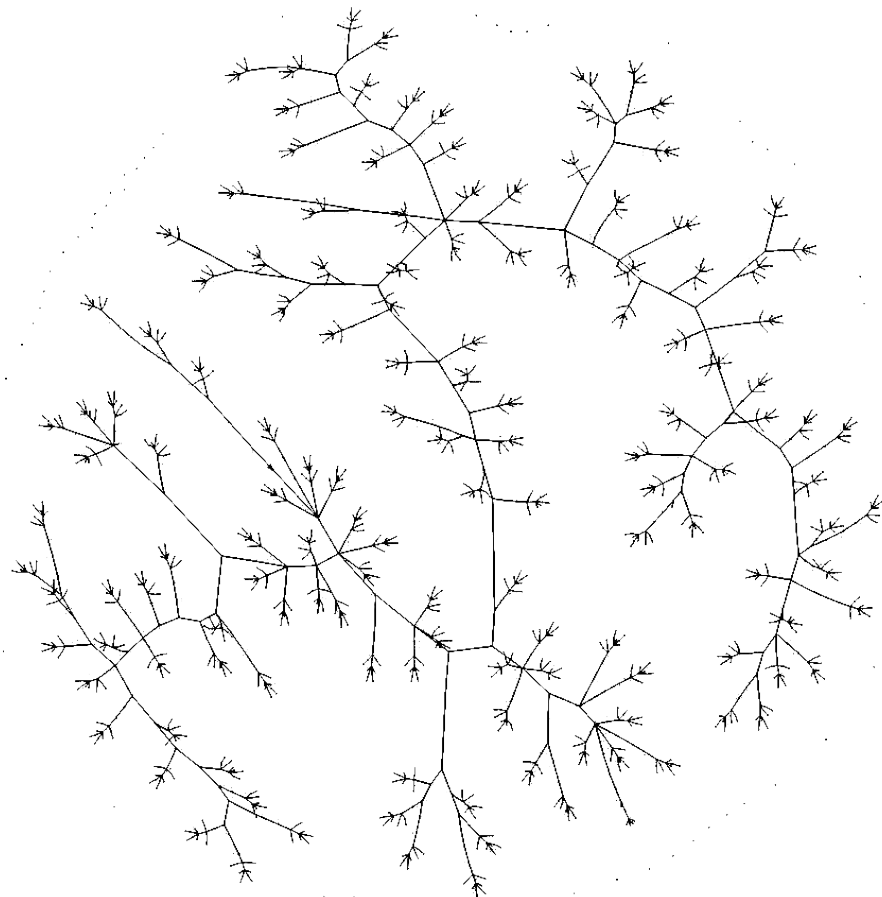
New model of type

energyStorage

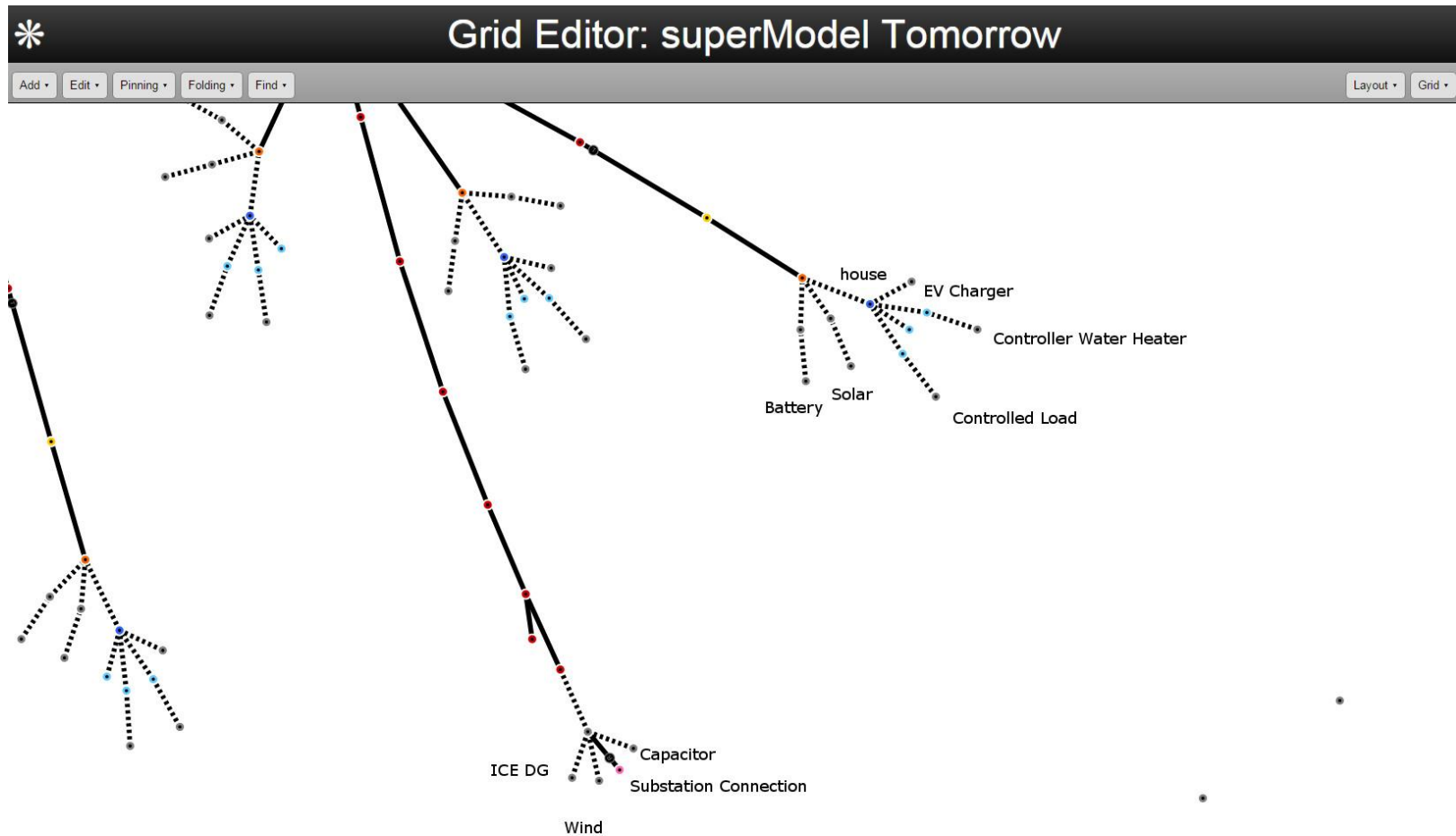
Create Model

OMF Interactive Feeder Editor

Grid Editor: superModel Tomorrow

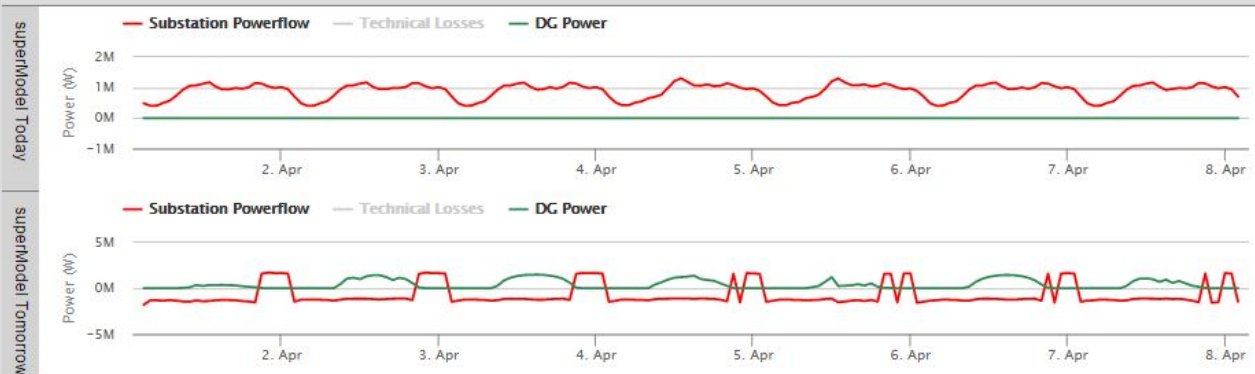


Feeder Detail with Solar + Storage

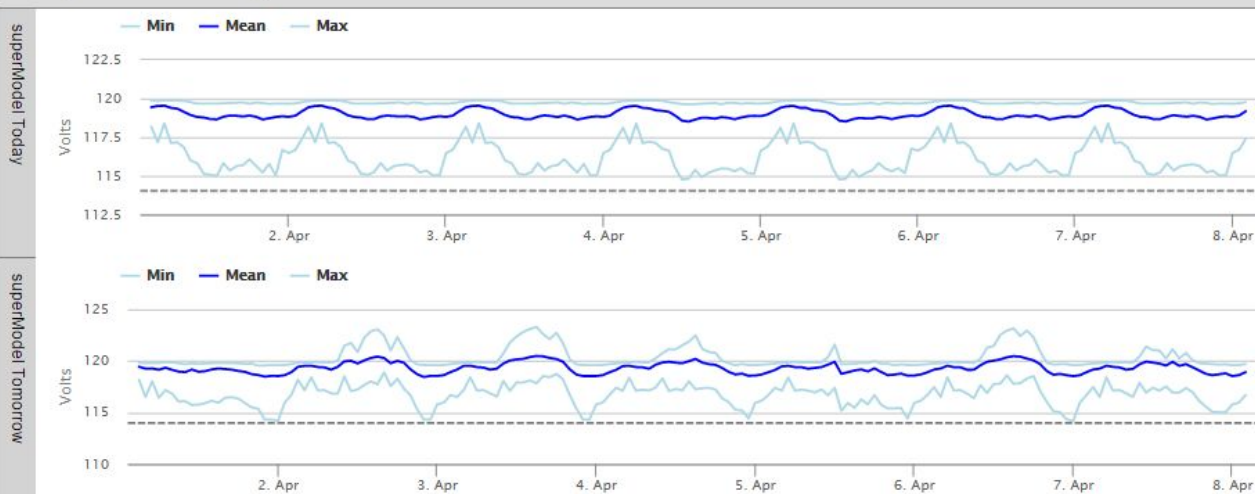


Results of GridLab-D Run

Power Consumption From Transmission System [Hide / Show](#)



Triplex Meter Voltages [Hide / Show](#)



- Powerflow and meter voltage are among the results calculated
- Also performs economic analysis

Topics

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The future

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 → 1 = 99 % reduction in cyber response time

SOLAR FREAKIN', ROADWAYS

- <http://www.youtube.com/watch?v=qlTA3rnpgzU>
- 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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**National Rural Electric
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