

Smart Grid Technologies: Building the Integrated Grid

Innovative Energy Technologies Conference
Sanford C. Bernstein
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Uncertainty and the Future

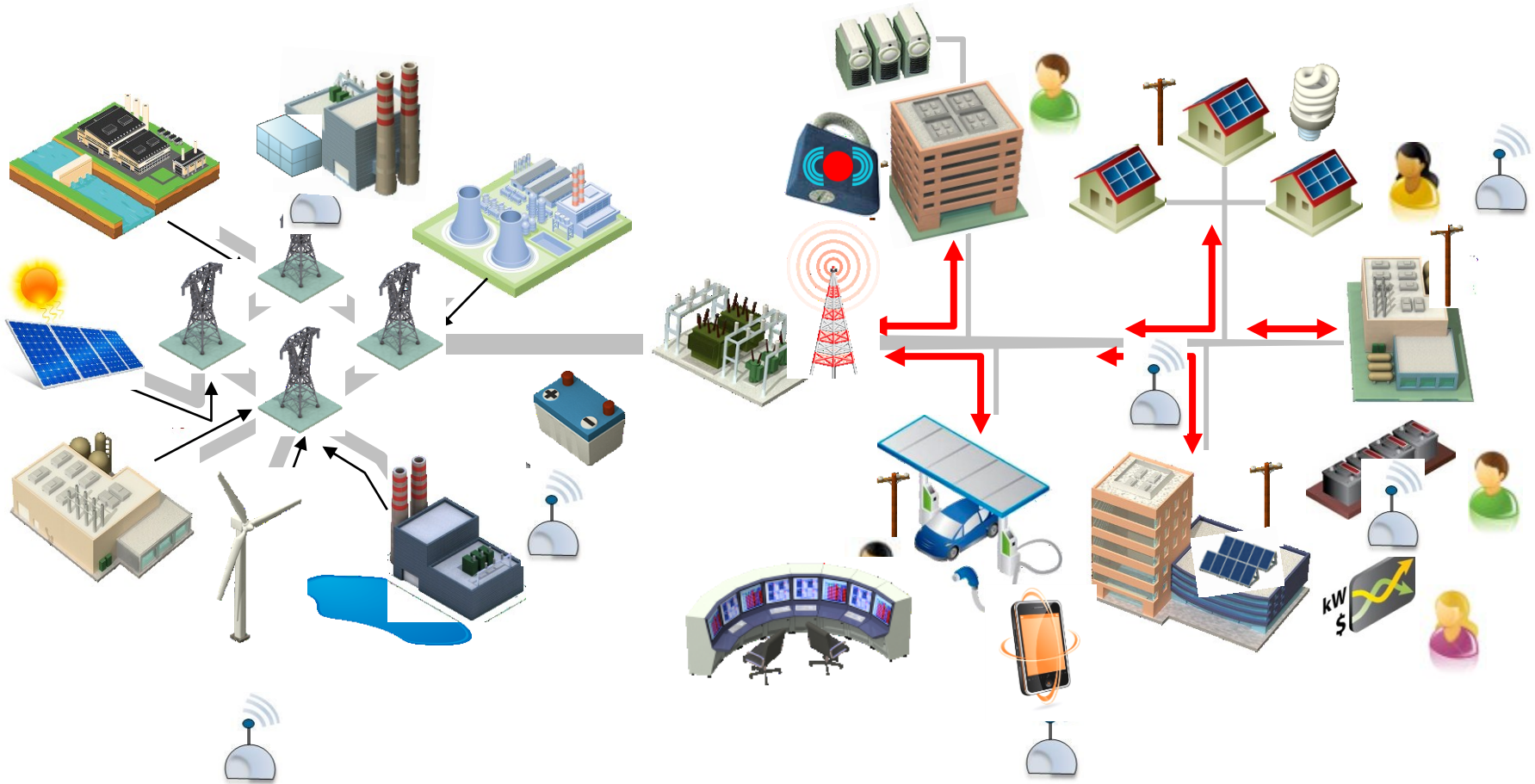
*The most important things
are unknown or unknowable*
– Edwards Deming

THERE ARE KNOWN KNOWNS
THERE ARE THINGS THAT WE KNOW THAT WE KNOW, THERE ARE
KNOWN UNKNOWNNS
THAT IS TO SAY, THERE ARE
THINGS THAT WE NOW KNOW WE DON'T KNOW
BUT THERE ARE ALSO
UNKNOWN UNKNOWNNS
THERE ARE THINGS
WE DO NOT KNOW
WE DON'T KNOW
AND EACH YEAR WE DISCOVER
A FEW MORE OF THOSE
UNKNOWN
UNKNOWNNS



*The future has a way of
arriving unannounced*
– George Will

Transformation of the Power System



**A Highly Interconnected Power System
that Optimizes Energy Resources**

Emerging Technologies

Rooftop Solar



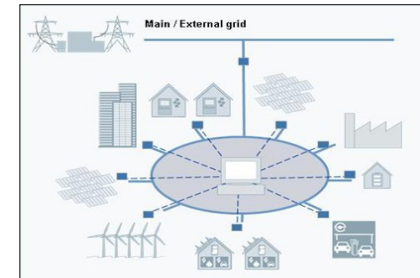
Battery Storage

Home Energy Management



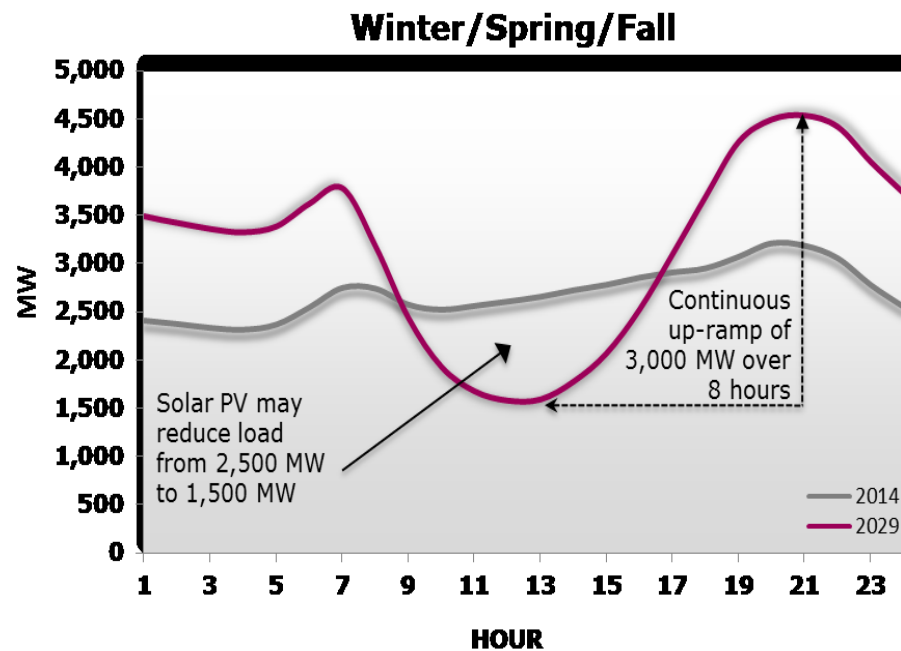
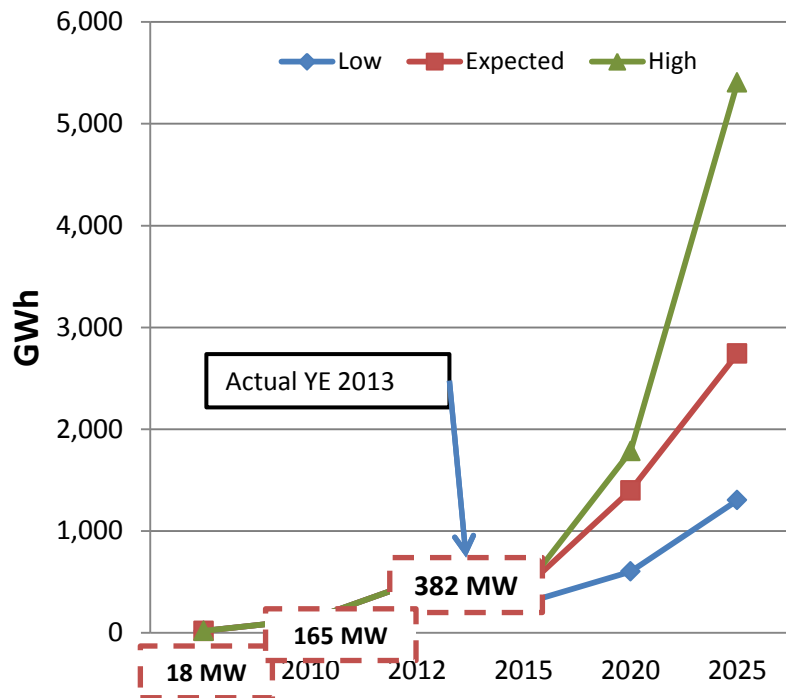
Electric Vehicles

Fuel Cells



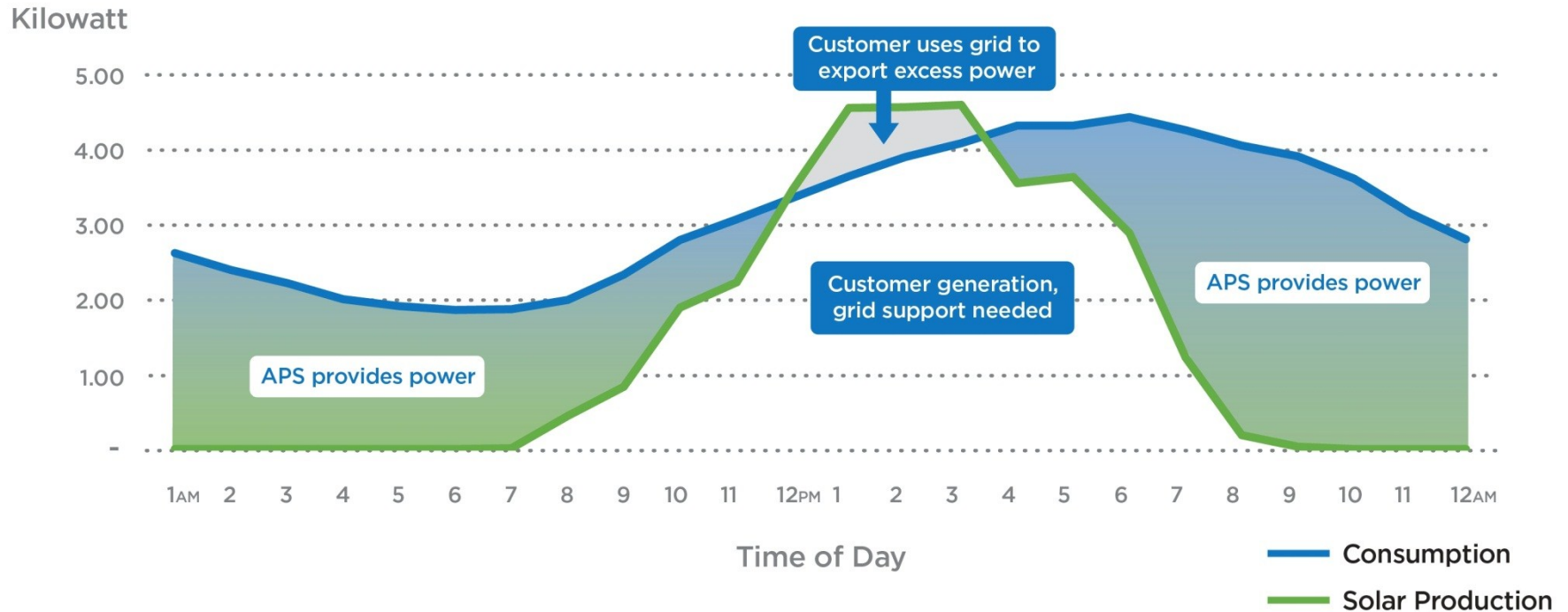
Microgrids

Rooftop Solar

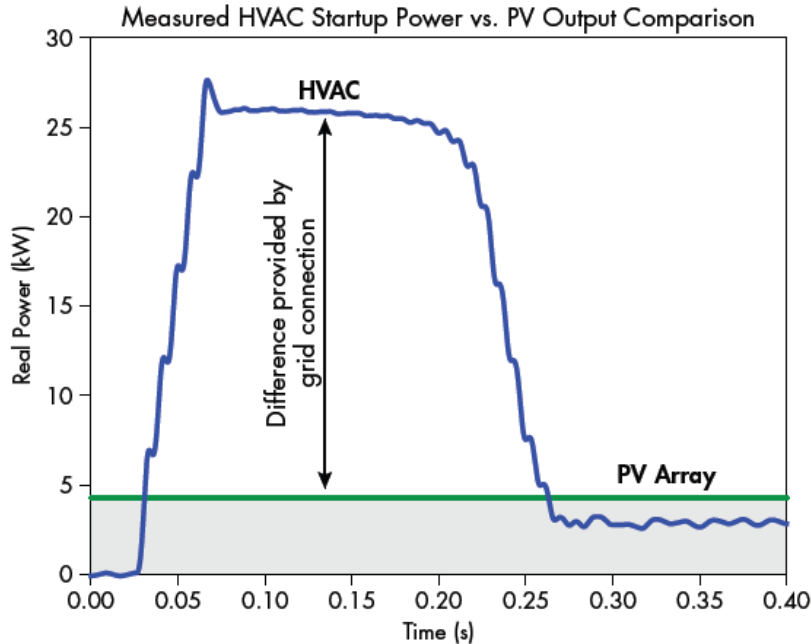


Rooftop Solar and the Grid

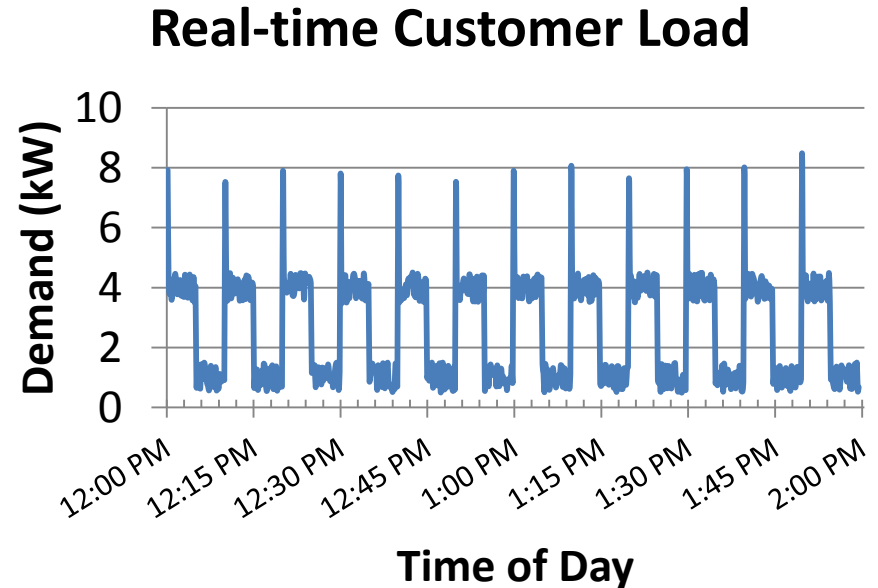
TYPICAL GRID INTERACTION FOR ROOFTOP SOLAR



Customer Loads and System Support



The grid provides real-time voltage and power needed to start air conditioners and other motors loads



This service is not observable in average hourly billing

Rates Need Updating

What's Changing

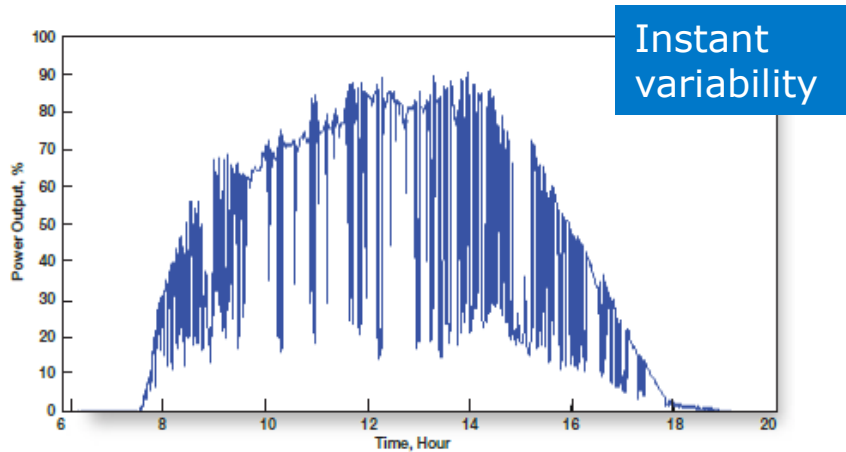
Customers are producing and consuming energy in new and innovative ways



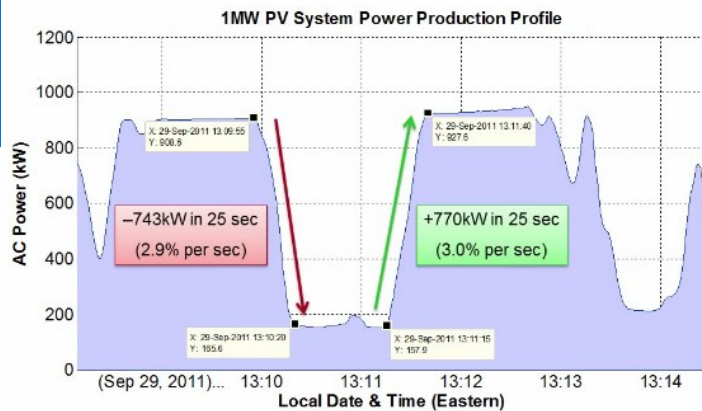
What's Needed

- **Safe and reliable power supply available to all customers when they need it**
- **Utility rates that recover the cost of infrastructure investments from customers based on services provided**
- **Modernized utility rate design that manages cost impacts to participant and non-participant customers**

Operations Challenges: High Penetration



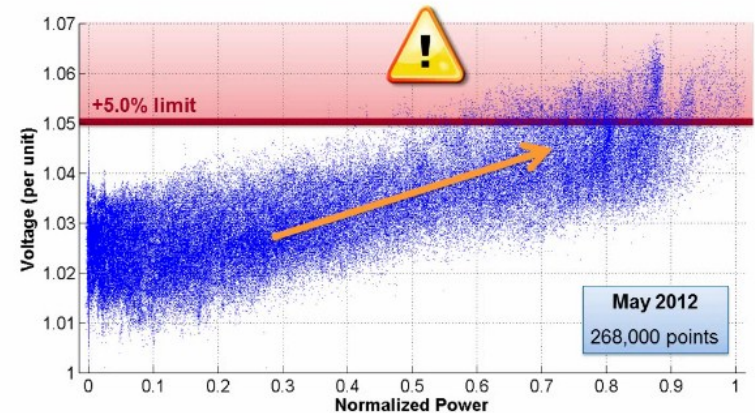
Power Ramp Events on Partly Cloudy Day
High definition power profile of 1MW plant at 1-sec resolution



Steep ramp rate of backup generation

Circuit J1: Voltage Exceeds Planning Limit

10-second average PV plant service voltage often above +5% at midday



Voltage control at distribution level

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Integrated Grid Building Blocks

- Highly advanced operational platforms
- Robust system health/situational awareness, both local and regionally
- Remote operation of the distribution system



EMS/ADMS

Status: Currently connected

Signal strength

26dB

Duration: 16 hours

Access point: 00:18:0a:31:07:21

SSID: Meraki

Channel: 149 - 5.745 GHz (11n, 40Mhz channel)

Packets: 53899 sent, 244320 received

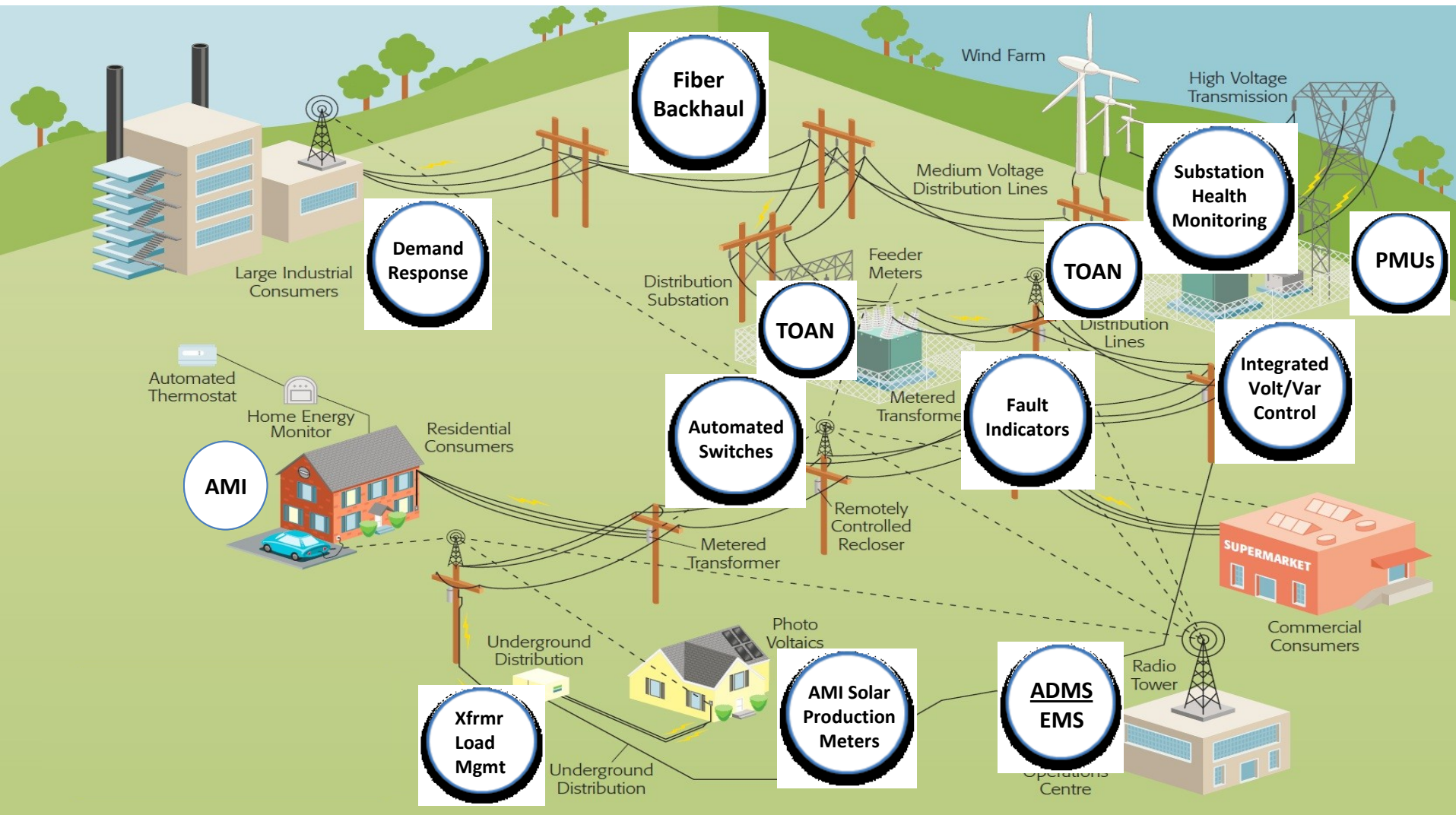
Data: 6.9 MB sent, 22.8 MB received

Communicating
Devices



Automated
Switching

Integrated Grid: Technologies



APS 5-Year Deployment Plan

Integrated Volt/VAR Control (IVVC)



Advanced Distribution Management System



Energy Management System (EMS) Upgrades

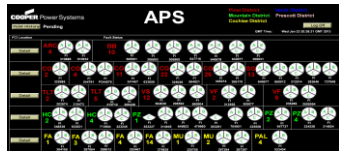


Synchrophasors (WISP)



***Deploying Over 5,000 Field Devices
Investing \$170 million***

Substation Health Monitoring



Communicating Fault Indicators (CFI)

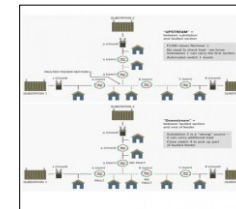
Strategic Fiber



Smart Meters



Supervisory Controlled Switches



2013 Benefits include over 1,000,000 customer outage minutes avoided

Current Arizona Activities

- Quarterly reports on distributed energy activity
- Innovations & Technology workshop series
- Cost and Value of Distributed Generation workshop series
- Energy Efficiency/Integrated Resource Plan workshop series

Building for the Future

