Tucson Electric Power

JEFF KRAUSS

MANAGER, RENEWABLE ENERGY RESOURCES

PV SYMPOSIUM MAY 3, 2018

TEP

Tucson Electric Power

1892-2017

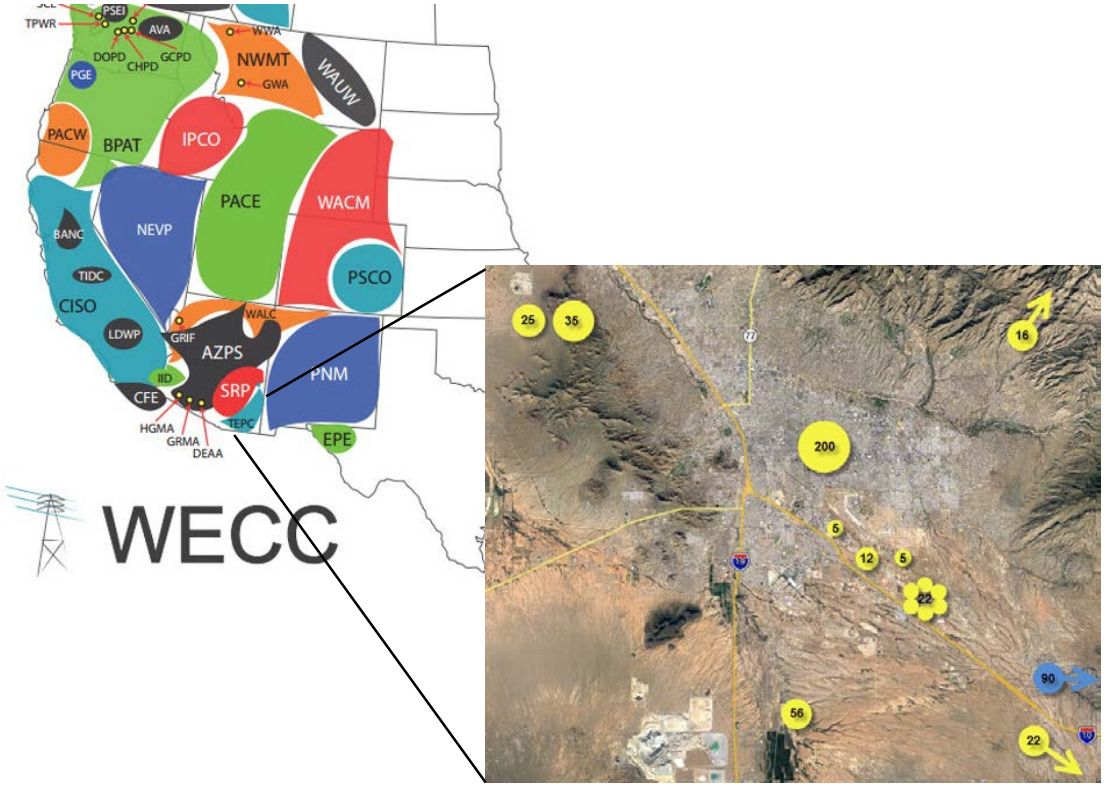
125 YEARS OF SERVICE

TEP

Tucson Electric Power

- ~420,000 customer over 1,000 square miles
- Vertically integrated w/ Balancing Authority
- 1,000 MW winter peak
- 2,500 MW summer peak

Arizona Corporation Commission



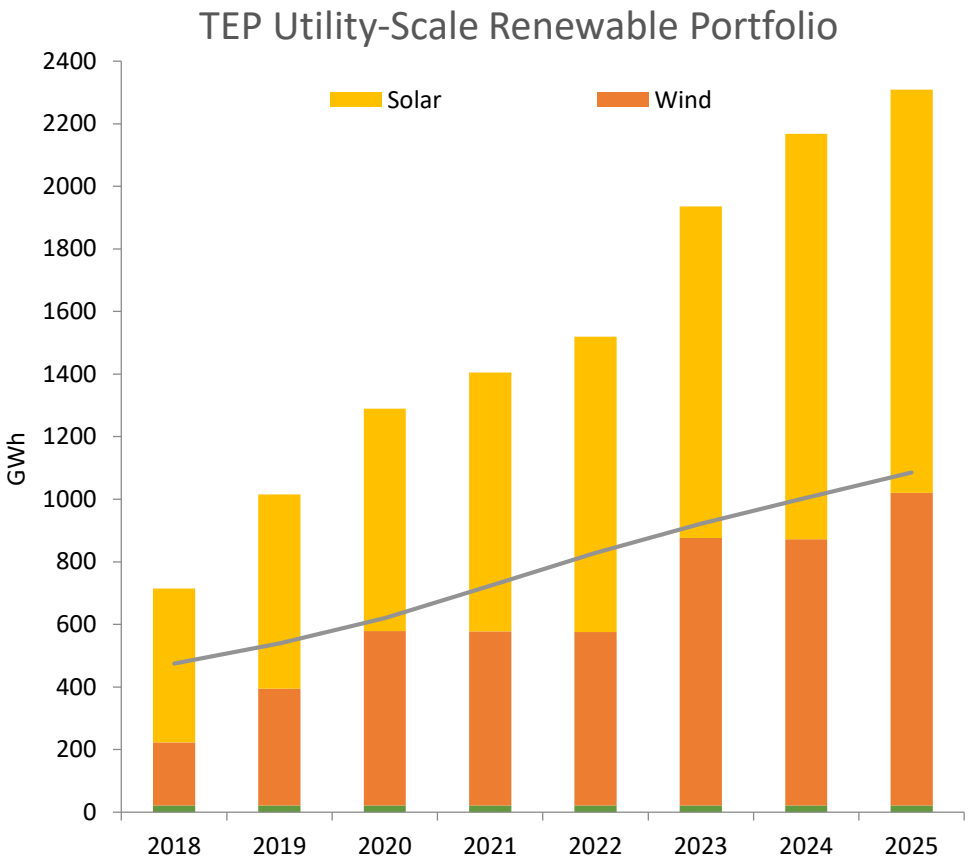
TEP
1892-2017
125 YEARS OF SERVICE

Arizona Renewable Energy Standard
TEP's Goals

- **Annual renewable goals increase 1% each year to 15% in 2025**
  - 8% in 2018

TEP's Commitment

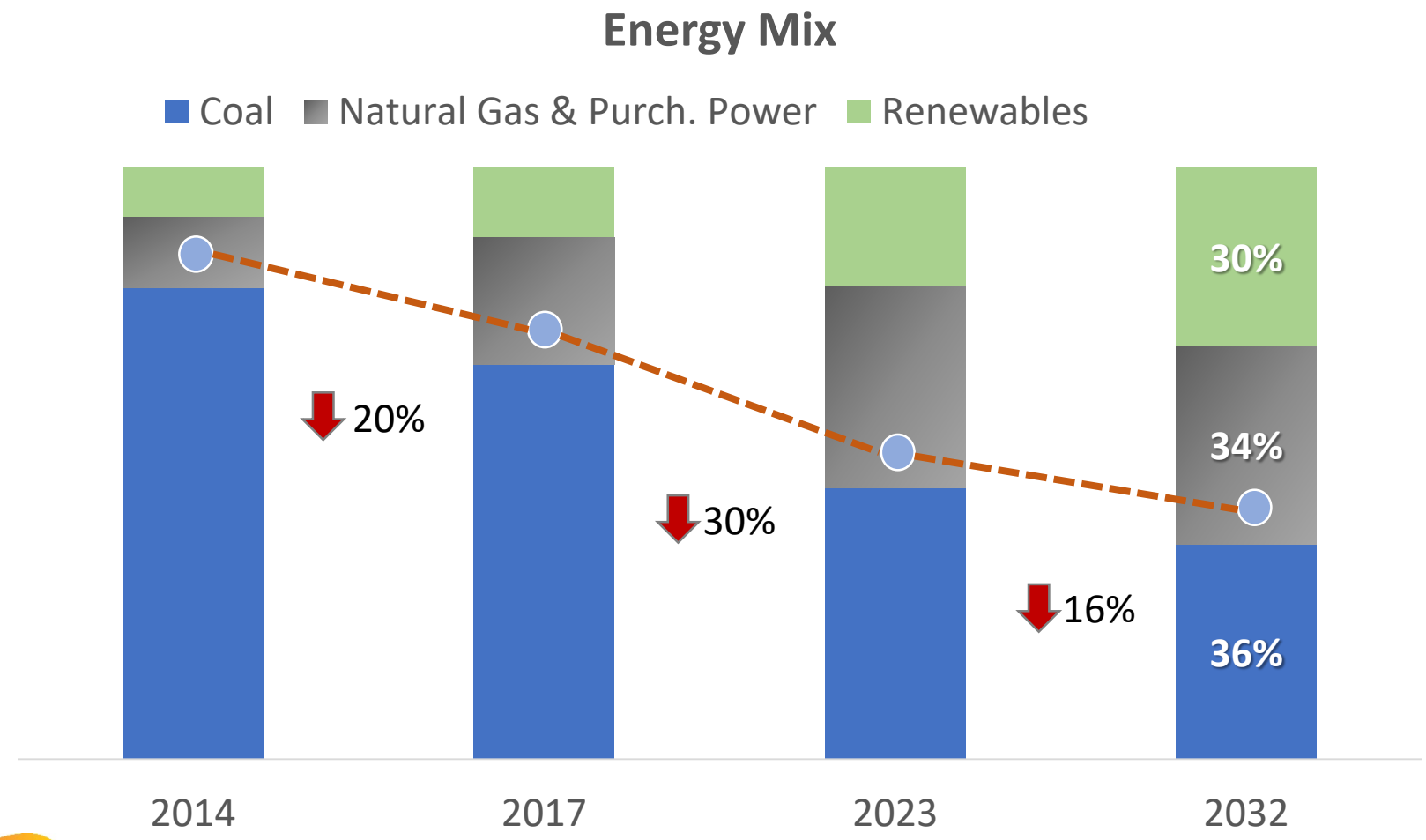
- **TEP plans to reach 30% by 2030**
- **Planned additions of 800-1000 MW over next 10 years**



*Does not include DG

TEP
1892-2017
125 YEARS OF SERVICE

Diversifying TEP's Resource Portfolio



TEP
1892-2017
125 YEARS OF SERVICE

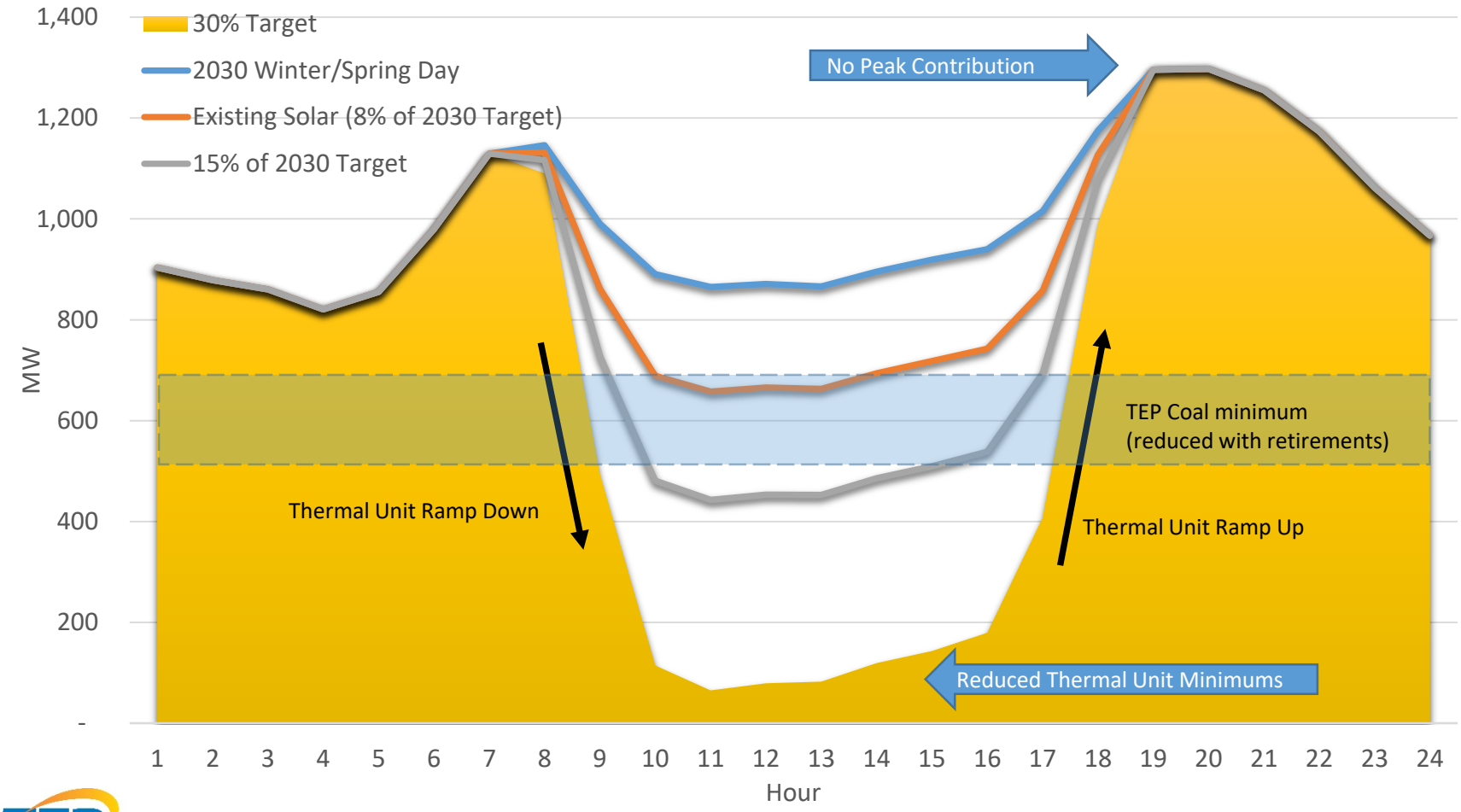
TEP and Renewables

- ≈ 350 MW Utility-Scale
  - Wind (80MW)
  - Solar (270MW, mostly PPA)

- ≈ 240 MW Residential and Commercial Distributed Generation (DG)
  - Additional ~40 MW in 2017

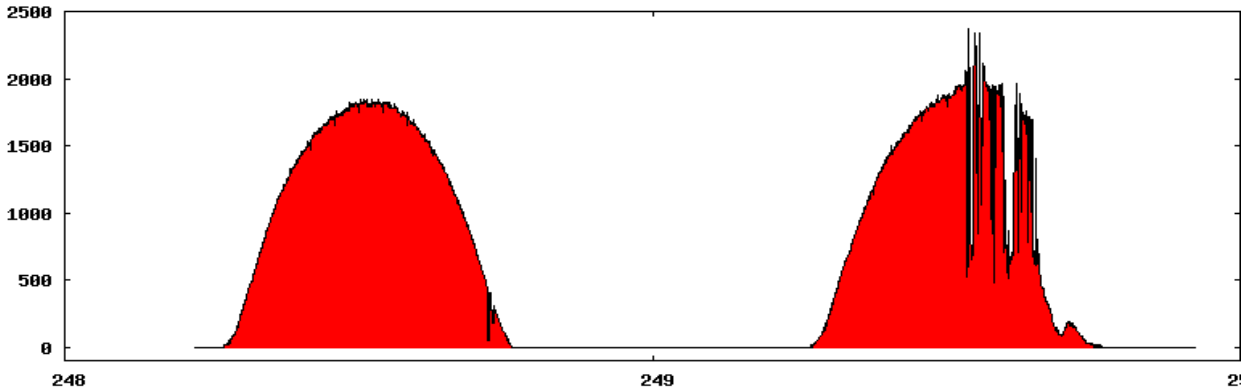
TEP
1892-2017
125 YEARS OF SERVICE

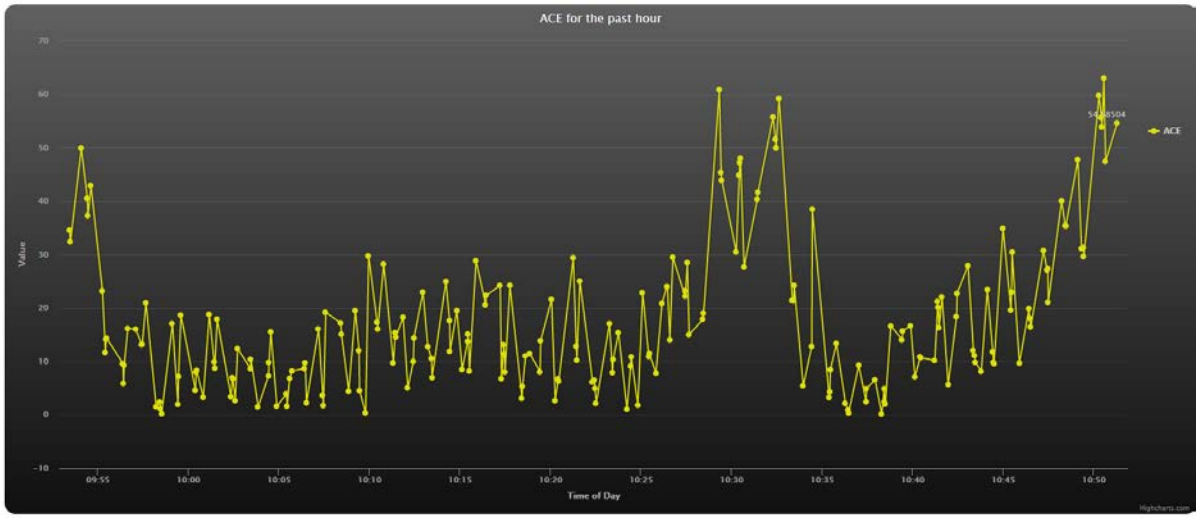
TEP's Roller Coaster



TEP
1892-2017
125 YEARS OF SERVICE

Operator Challenges From Intermittency





TEP
1892-2017
125 YEARS OF SERVICE

Overview of Problems

- Frequency support reserves requirement
  - Increased # of spinning generators
  - Must back up renewables generation
  - New BAL-003 Standards
- TEP Increasing Renewables
  - Over generation in day
  - Ramping to meet peak
  - Renewable firming expense
- Voltage during faults
  - Remote generation creates “soft spots” near load results in oscillations
  - Voltage falls to 0.6PU on 138kV lines for 5 cycles
  - Residential DG disconnects
- Energy Delivery
  - Low voltage in summer
  - High voltage in winter
  - Single phase return power
  - Optimizing power delivery

TEP
1892-2017
125 YEARS OF SERVICE

Is an Energy Storage System the Answer?

Why Homer is <u>Wrong</u>

TEP
1892-2017
125 YEARS OF SERVICE

RFP Process
Use Case Assumptions

- Solon selected to author Use Case:
  - 325kW BESS installed at U of A Tech Park
  - Studying frequency response

SOLON

- 10 MW ESS would be large enough to have a meaningful effect and still be economically viable

- 10 MW only represents a small % of TEP peak load. Best use would be for frequency response device

- An ESS would be more effective and economic in meeting requirements for NERC BAL-003-1

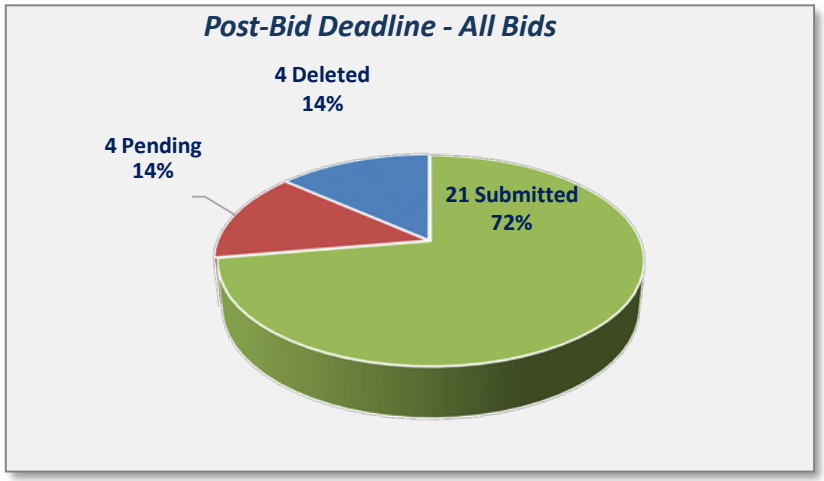
RFP Timeline

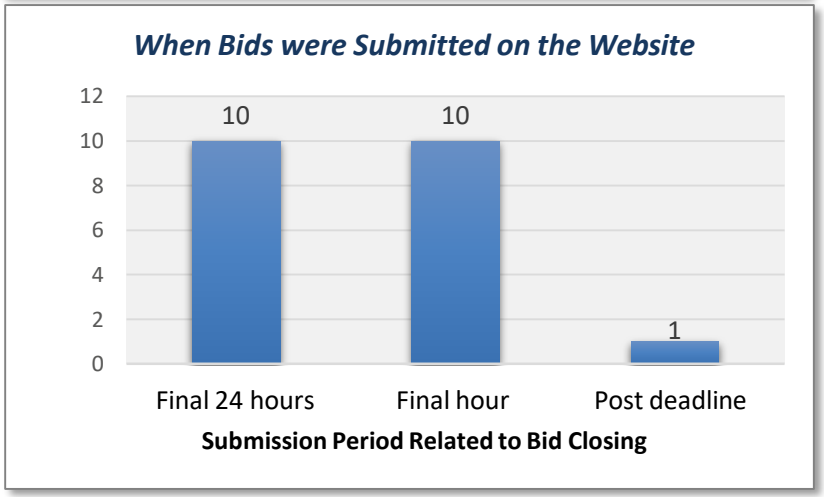
• ESS RFP in Implementation plan	July 2014
• Solon Corp hired to write use case	Sept 2014
• Use Case completed	March 2015
• RFP released	April 2015
• Bidders Conference	May 2015
• Site Walk	May 2015
• RFP Closed	June 2015
• Winner(s) Selected	August 2015
• ESS contract(s) Execution	February 2016
• Ground Breaking	March 2016
• C.O.D 1	January 27, 2017
• C.O.D. 2	March 31, 2017

2 1/2 Years from inception to COD

TEP
1892-2017
125 YEARS OF SERVICE

RFP Results





Technology Type	Number of Submitted Bids
Battery	20
Flywheel	1
Battery Type	**Number of Short Listed Bids**
NMC - Lithium-ion	3
LTO - Lithium Titanate	2
LFP – Lithium Iron Phosphate	1
LIP – Lithium Polymer	1
Total	**7**
Battery Manufacturer	**Number of Short Listed Bids**
LG Chem	3
BYD	1
Samsung SDI	1
Toshiba	2
Total	**7**

TEP
1892-2017
125 YEARS OF SERVICE

Winning Storage Projects

1. **NextEra Energy Resources**
   - 10MW lithium nickel-manganese-cobalt battery, 15 minute duration (2.5 MWh)
   - DeMoss-Petrie Substation

Next Era's Pima Energy Storage System (PESS)

2. **E.On Climate & Renewables**
   - 10MW lithium Titanate oxide battery, 15 minute duration (2.5 MWh)
   - **Combined with 2.4 MWdc Solar PV**
   - U of A Science and Tech Park

EC&R's Iron Horse Energy Storage System

TEP
1892-2017
125 YEARS OF SERVICE

TEP / EON
Iron Horse Utility Scale PV + Storage Project

Project Description

Located in Tucson, Arizona at the University of Arizona Tech Park complex

Energy Storage (10MW / 2.5 MWh) co-located to a solar PV array 2MWac-2.4MWdc

Technology Selection

Lithium Titanate Battery (LTO) manufactured by Toshiba (sold though Landys & Gyr subsidiary)

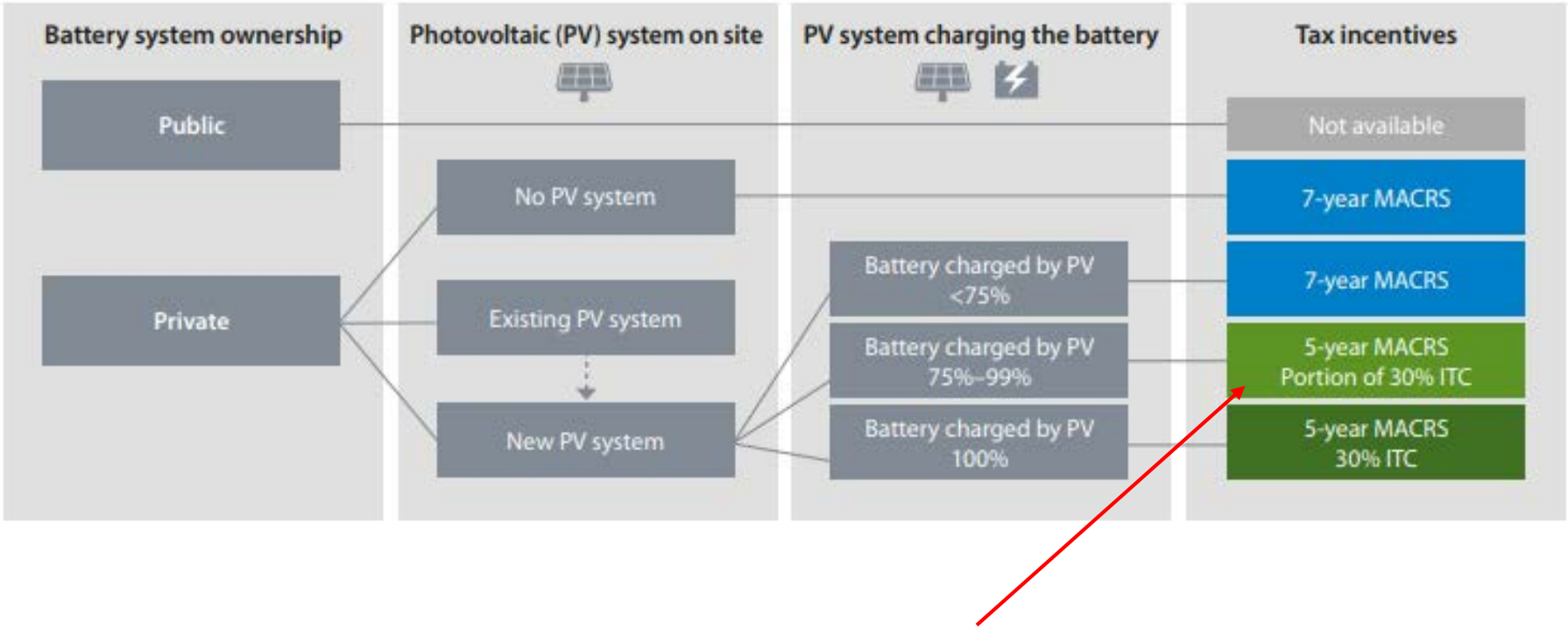
Energy Management System provided by Greensmith/Wärtsilä

Integration

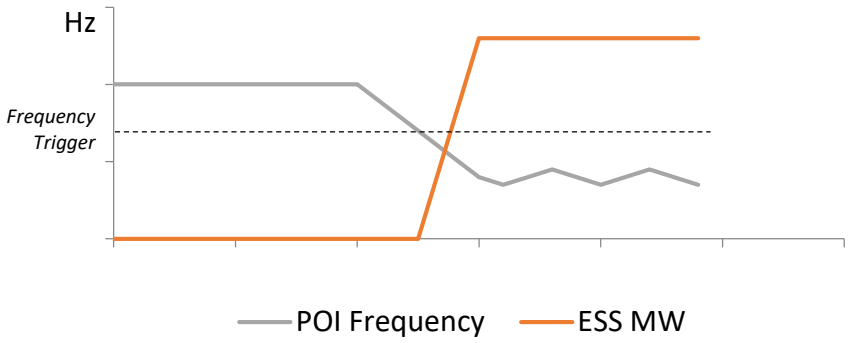
Energy storage system integral part of the solar PV array and eligible for Investment Tax Credit

TEP
1892-2017
125 YEARS OF SERVICE

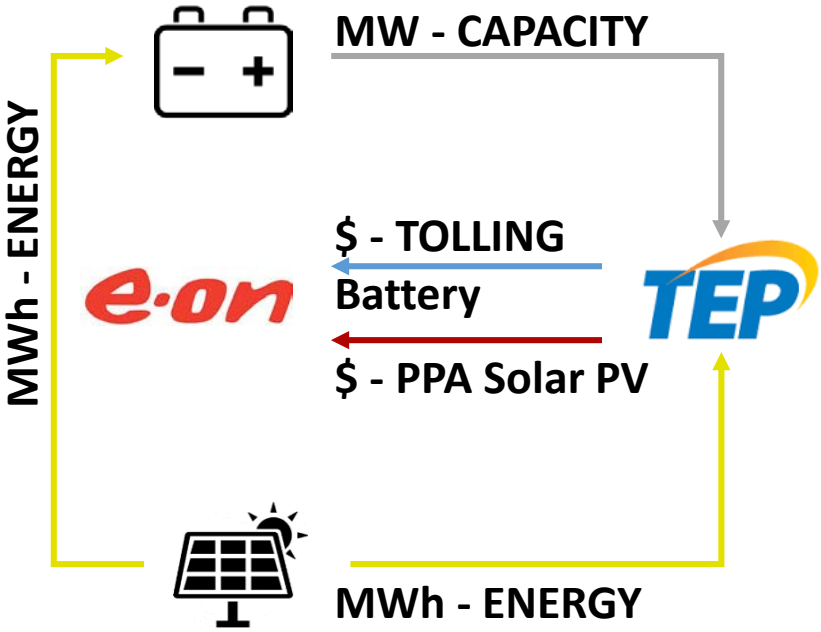
Decision Tree
Federal Tax Incentives for Energy Storage Systems



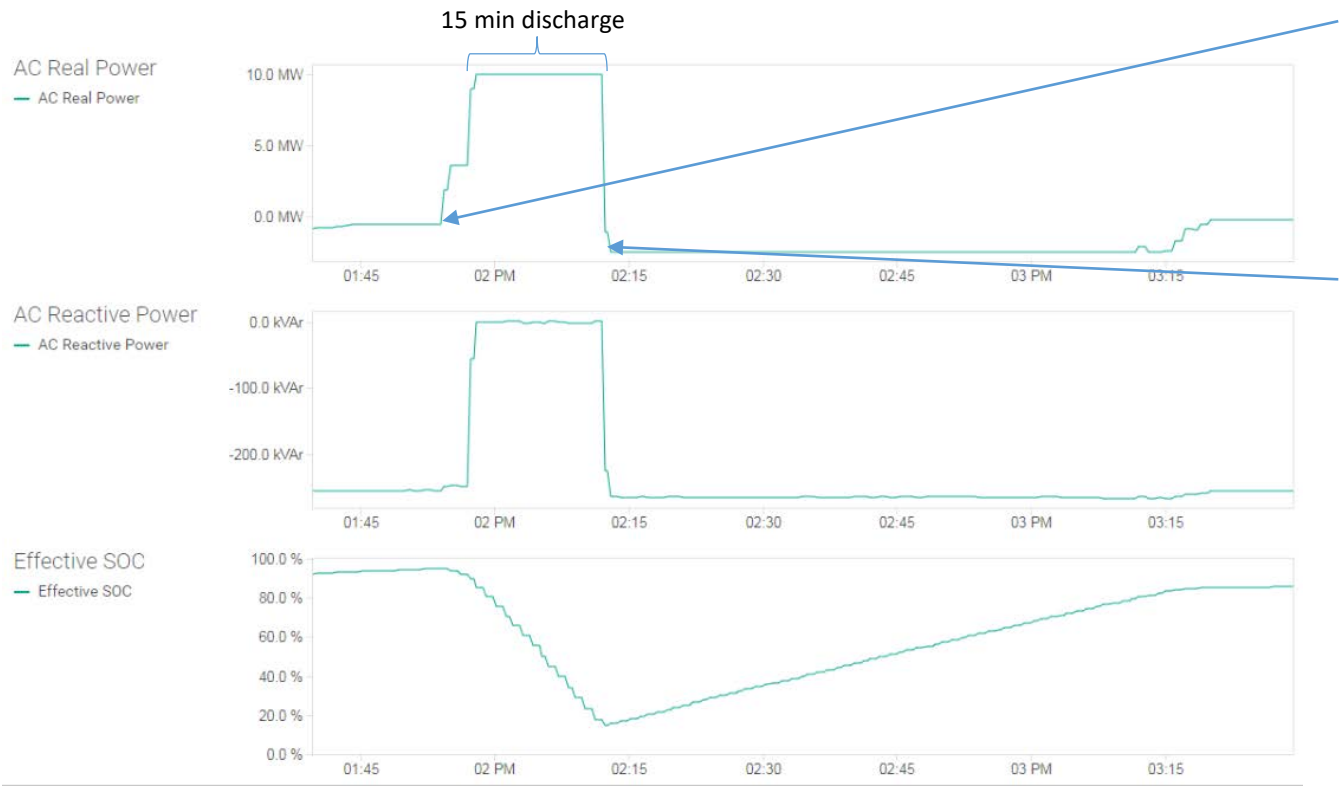
Operational and Contractual Structure



- The Energy Storage System will automatically deliver real power when the POI frequency falls outside the programmed deadband
- The Energy Storage System must respond within 1 second
- The response is proportional to the frequency deviation up to a maximum deviation



Data from a frequency response event – Iron Horse battery providing 15 minutes response



Upon frequency drop in TEP grid, the battery responds and starts to dispatch. Increase in response based on frequency reduction thresholds

Following the frequency event, the battery charge to recover State Of Charge and be ready for the next event

State Of Charge of the battery decreases following battery discharge and recovers when the battery starts to charge

GEMS (Greensmith Energy Management Software)

Future = More PV + Storage

- **100 MW Wind – COD mid-2020**
  - NextEra Energy Resources
  - New Mexico wind
  - Existing Transmission Capacity
- **100 MW Solar + 30 MW Energy Storage – COD end of 2020**
  - NextEra Energy Resources
  - Peak shifting
  - Sub-$30 per MWh for solar energy
  - 4-hour duration storage
- **Wind RFP**
  - 150 MW w/ associated transmission
  - ~47% capacity factor
  - Complements solar production

TEP
1892-2017
125 YEARS OF SERVICE

Future = More PV + Storage

- **Energy Storage Task Force**
  - Identifying use cases for future storage up to ~70 MW
  - Solutions looking for problems
  - Batteries can do a lot of things, but only 1 or 2 really well
- **Arizona Energy Modernization Plan**
  - 80% Clean Resources by 2050
  - 3,000 MW of storage
    - Batteries, pumped, compressed air, etc.
    - 2,000 pumped-storage hydro in development – Big Chino
  - Biomass
    - 50,000 acres per year ~60 MW per year
  - Electric Vehicles
  - Revamped Energy Efficiency

TEP
1892-2017
125 YEARS OF SERVICE

Thank you!

JKRAUSS@TEP.COM




TEP
Tucson Electric Power
1892-2017
125 YEARS OF SERVICE