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
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*
Diversifying TEP’s Resource Portfolio

Energy Mix

2014: 20% Coal, 34% Natural Gas & Purch. Power, 36% Renewables
2017: 30% Coal, 34% Natural Gas & Purch. Power, 36% Renewables
2023: 30% Coal, 34% Natural Gas & Purch. Power, 36% Renewables
2032: 30% Coal, 34% Natural Gas & Purch. Power, 36% Renewables
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’s Roller Coaster

- 30% Target
- 2030 Winter/Spring Day
- Existing Solar (8% of 2030 Target)
- 15% of 2030 Target

- Thermal Unit Ramp Down
- Thermal Unit Ramp Up
- Reduced Thermal Unit Minimums
- TEP Coal minimum (reduced with retirements)
- No Peak Contribution

MW
Hour
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Operator Challenges From Intermittency
Overview of Problems

- Frequency support reserves requirement
  - Increased # of spinning generators
  - Must back up renewables generation
  - New BAL-003 Standards

- 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

- TEP Increasing Renewables
  - Over generation in day
  - Ramping to meet peak
  - Renewable firming expense

- Energy Delivery
  - Low voltage in summer
  - High voltage in winter
  - Single phase return power
  - Optimizing power delivery
Is an Energy Storage System the Answer?

Why Homer is **Wrong**

- Trying is the first step towards failure.
- Why must life be so hard?
- Still not clean. Stink of failure still on me.
RFP Process
Use Case Assumptions

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

• 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
# RFP Results

## Post-Bid Deadline - All Bids

- **4 Deleted** (14%)
- **4 Pending** (14%)
- **21 Submitted** (72%)  

## Technology Type

<table>
<thead>
<tr>
<th>Technology Type</th>
<th>Number of Submitted Bids</th>
</tr>
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<tbody>
<tr>
<td>Battery</td>
<td>20</td>
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<tr>
<td>Flywheel</td>
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## Battery Type

<table>
<thead>
<tr>
<th>Battery Type</th>
<th>Number of Short Listed Bids</th>
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<tbody>
<tr>
<td>NMC - Lithium-ion</td>
<td>3</td>
</tr>
<tr>
<td>LTO - Lithium Titanate</td>
<td>2</td>
</tr>
<tr>
<td>LFP – Lithium Iron Phosphate</td>
<td>1</td>
</tr>
<tr>
<td>LIP – Lithium Polymer</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7</strong></td>
</tr>
</tbody>
</table>

## Battery Manufacturer

<table>
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<tr>
<th>Battery Manufacturer</th>
<th>Number of Short Listed Bids</th>
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<tbody>
<tr>
<td>LG Chem</td>
<td>3</td>
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<tr>
<td>BYD</td>
<td>1</td>
</tr>
<tr>
<td>Samsung SDI</td>
<td>1</td>
</tr>
<tr>
<td>Toshiba</td>
<td>2</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>7</strong></td>
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## When Bids were Submitted on the Website

<table>
<thead>
<tr>
<th>Submission Period Related to Bid Closing</th>
<th>Number of Bids</th>
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<tbody>
<tr>
<td>Final 24 hours</td>
<td>10</td>
</tr>
<tr>
<td>Final hour</td>
<td>10</td>
</tr>
<tr>
<td>Post deadline</td>
<td>1</td>
</tr>
</tbody>
</table>

**Final 24 hours**

- 10

**Final hour**

- 10

**Post deadline**

- 1
Winning Storage Projects

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

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
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
Decision Tree
Federal Tax Incentives for Energy Storage Systems
• 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
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
Thank you!

JKRAUSS@TEP.COM