West Coast Irrigation Efficiency

E3T Emerging Technologies Showcase

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September 28, 2015
Sponsored by BPA’s E3T Program
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- Minimize or maximize control panel
- Phone lines are muted
- Please use question pane to ask questions at any time, or if you have any technical issues

NOTE: Today’s presentation is being recorded and will be available at http://e3tnw.org/Webinars
Irrigated Agriculture and BPA

By Tom Osborn – BPA

Sept 28, 2015
• Who is BPA
• Saving water, saving energy
• EE Projects with Irrigation Districts
• EE with our utility customers
• Trade Allies
• APS
• Questions
BPA Markets Power from 31 Federal Hydropower Plants (21 COE/10 BOR) (6,195 ave. MW; 13,898 sustained Peak), Columbia Generating Station Nuclear Plant and some non-Federal hydro and wind

- Sustained Firm Capacity = 16,000 MW; Firm Energy = 70,000 GWH/yr

- More than 80% of the power BPA sells is hydroelectric; about 50% of the region’s electricity comes from hydropower

- BPA accounts for about 45% of the electric power consumed within the Region

- Canada has 15% of basin area, but provides 30% of 134 million acre feet (maf) average annual flow at The Dalles

- Transmission intertied to CA.
• BPA utilities saved 1,584 aMW since 1982
• BPA invested over $3B in EE
• Region’s public power goals are 100aMW per year
• Ag is 4% of portfolio
PNW 6.8 Million Irrigated Acres

- Sprinkler: 25%
- Gravity: 3%
- Drip: 72%
Sprinkler System Type

- Center Pivot < 30 psi: 22%
- Center Pivot 30-59 psi: 32%
- Center Pivot > 60 psi: 6%
- Linear Move Tower: 16%
- solid Set: 8%
- Side Roll: 6%
- Big Gun: 6%
- Hand Move: 5%
- Drip: 3%
How is EE Saving Water

- Agrimet (BPA and USBR in 1981)
- Scientific Irrigation Scheduling (300,000 acres)
- Better sprinklers/nozzles to improve uniformity, reduce drift
- Gaskets to reduce leakage, improve uniformity
- Pump Testing
- VFDs to pump less water when not needed
- Irrigation system controls (pumps, zone, DR)
- Pivots with VRI/VSI, MESA or LEPA/LESA
- Piping and Lining canals
Scientific Irrigation Scheduling

- Uses Agrimet or other weather stations
- Consultants use crop, soil, weather data
- Minimum weekly visit (typically Neutron Probe)
- Others using other equipment
- BPA sees 10% water savings
- Incentive $5.20 per acre
- More baseline studies underway

- Washington State University created smart phone application for irrigation scheduling WSUISM
USBR AgriMet Stations
<table>
<thead>
<tr>
<th>Sprinkler Equipment</th>
<th>Payment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replace worn nozzle with new flow controlling type nozzle for impact sprinklers</td>
<td>$4.00/nozzle</td>
</tr>
<tr>
<td>Replace leaking impact sprinkler with rebuilt or new impact sprinkler</td>
<td>$3.75/sprinkler</td>
</tr>
<tr>
<td>New nozzle for impact sprinkler replacing existing worn nozzle of same flow rate or less</td>
<td>$1.50/nozzle</td>
</tr>
<tr>
<td>New nozzle for center pivot and lateral moves</td>
<td>$1.00/nozzle</td>
</tr>
<tr>
<td>New rotating type sprinklers that replace impact sprinklers</td>
<td>$4.00/sprinkler</td>
</tr>
<tr>
<td>Replace leaking pipe section and riser cap gaskets for wheel or hand lines or portable main line gasket with new gasket</td>
<td>$2.75/gasket</td>
</tr>
<tr>
<td>New low-pressure regulators</td>
<td>$5.00/regulator</td>
</tr>
<tr>
<td>New rotating type sprinklers that replace low-pressure</td>
<td>$4.00/sprinkler</td>
</tr>
<tr>
<td>New multiple configuration nozzles for low-pressure pivot sprinklers</td>
<td>$3.00/sprinkler</td>
</tr>
<tr>
<td>New multi-trajectory sprays that replace impact sprinklers</td>
<td>$4.00/sprinkler</td>
</tr>
<tr>
<td>New multi-trajectory sprays that replace low-pressure sprinklers</td>
<td>$1.00/sprinkler</td>
</tr>
<tr>
<td>Replace leaking drain gaskets with new gaskets on wheel-lines, hand lines or pivots</td>
<td>$1.00/drain</td>
</tr>
<tr>
<td>New hubs for wheel-lines</td>
<td>$14.50/hub</td>
</tr>
<tr>
<td>New goose-neck elbow for new drop tubes (to convert existing sprinkler equipment mounted on top of the pivot to low-pressure sprinkler package)</td>
<td>$1.65/goose-neck</td>
</tr>
<tr>
<td>New drop tube for low-pressure pivot sprinklers (minimum three feet length)</td>
<td>$3.00/drop tube</td>
</tr>
<tr>
<td>Replace leaking center pivot base boot gasket with new gasket</td>
<td>$175.00/pivot</td>
</tr>
<tr>
<td>Pipe repair of leaking hand lines, wheel-lines and portable mainline</td>
<td>$10.03/pipe section</td>
</tr>
<tr>
<td>Rebuild or replace leaking or malfunctioning leveler with new or rebuilt wheel-line leveler</td>
<td>$0.75/leveler</td>
</tr>
</tbody>
</table>

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1. Rebate is limited to two units per sprinkled acre for solid set sprinklers.
2. Lateral moves are also included.
USBR Canal Lining

Energy Efficiency
Emerging Technologies
USBR Lateral Piping
E3T
Energy
Efficiency
Emerging Technologies
What's Happening Today

- BPA Funded NEEA reports on VRI/VSI for pivots and PAIL standards
- BPA continuing LEPA/LESA for 2016; maybe VRI
- BPA Reviewing our SIS program
  - What is market adoption? Percentage of water savings?
- BPA Agriculture Market Research
  - What are we doing right? Needs improvement? What are we missing?
  - Add new measures? (LEPA/LESA, irrigation system controls, data driven ag, WaterSense controllers for Turf, etc)
- Work closer with Trade Allies and Vendors
VRI/VSI

- BPA Funded NEEA to demonstrate VRI and VSI for center pivots
- Perform ground mapping/soil samples (EM)
- Create prescription to load into center pivot control box
- Install hydraulic sprinkler valves
- Cost $30-50K (or $400/acre)
- Takes active grower involvement
- Findings show that savings inconclusive; may not be cost effective for utility
- Very few conversions in PNW; See NEEA report
VRI Speed Control Prescription  VRI Zone Control Prescription

Crop
Aerial
Topography
Yield
EM/EC
Field

VRI
LEPA/LESA

• BPA Funded Washington State Univ and U of Idaho
• MESA – Mid Elevation Sprinkler Application
• LEPA – Low Energy Precision Application
• LESA – Low Energy (Elevation) Spray Application
• Pilot on a dozen center pivots in PNW
• Two years at some sites
• Seems to work on low growing crops, and even corn!
• Alfalfa tonnage increase (2 tons per acre) in water shortage
• BPA will review results and may add rebates in 2016
Pivot Sprinklers

Past: High Pressure Impacts

- Irrigation Efficiency ~60%
- Operating Pressure 60-80 psi
- Application rate: Medium
- Outlet Spacing ~20-30 ft
Pivot Sprinklers

**Present:** Mid Elevation Spray Application (MESA)

- Irrigation Efficiency ~85%
- Operating Pressure: ~40 psi.
- Application Rate: High
- Outlet Spacing: ~10ft
Pivot Sprinklers

Future: Low Elevation Precision Application (LEPA/LESA)

- Irrigation Efficiency ~97%
- Operating Pressure: ~15psi.
- Application rate: Very High
- Outlet Spacing: <5ft

E3T Energy Efficiency Emerging Technologies
Pivot Sprinklers
Pivot Sprinklers
Overview of LEPA/LESA Advantages

- **Irrigation efficiency** is much higher. You will use less water.
- **Low pressure**! Save pumping energy.
- **Less variation in application efficiency** (less day-night differences in applied depths, less difference between windy vs. calm days).
- **Less lodging**. Heavy and wet crops can fall over.
- **Less mold mildew**.
- **Wheel tracks**. It’s easier to keep them dry.
- **Dry canopy**. Possibly less crop diseases.
- Maintenance is easier. No ladders. Stay drier.
- **Better uniformity in corn**.
- **Inexpensive sprinklers** (about $1.82/head vs. $17.06)
Data Driven Agriculture

Data Models and Sensor based Technologies

Brian Bassett
H20-Optimizer

September 28, 2015
Integrating Sensor Technologies
Sensors identify Variability in Soil Profiles

Geophysical Data

Multi Spectral Imagery
Four Phases to Sensor Integration
Geophysical Sensors
(UAV) Unmanned Airborne Vehicle Sensors
UAV Multi-spectral Data
Timing is Everything….

- Agriculture is filled with critical windows influenced by the level of soil moisture:
  - Bloom
  - Emergence and bud break
  - Nutrition
  - Fruit and nut set
  - Thinning and sizing
  - Maturity
  - Harvest

- Correlating UAV imagery with validated soil moisture
  - Reduced pumping time
  - Validated irrigation targets
  - Lowered power consumption
  - Lowered equipment runtime
  - Minimized nutrient leaching

Sensors provide growers capability implement repeatable data driven decision.
Identify Target Field Capacities

Sampling depth determined by Intended crops rooting depth to be monitored.
Determine Frequency and Duration
Improve Nutrition Utilization

Without available water fertilizer is unavailable

Fertilizer becomes available to the roots between 50-100% field capacity

Without oxygen, absorption cannot occur
Common ET Irrigation Method

Water Pushed past the root zone
VRI Irrigation Method

Water Pushed passed the root zone

Root Depth

% Field Capacity

100%
70%
40%

Planting
Harvest
**Existing Irrigation System Management**

Colors represent existing blocks irrigation schemes.

Sensors required for each blocks soil profile and variety.

- Combination Frequency & Duration
- Medium Frequency & Duration
- Low Frequency & Long Duration

VFD and automated valve control suggested.

Irrigation schemes address the majority of up to 2 soil profiles.
Variable Rate Irrigation System Design

Colors represent similarly irrigated soil profiles.

Sets irregularly shaped utilizing same GPH emitter.

Sensors required for each differentiated soil profile and variety

VFD and automated valve control suggested
Scaling Sensor Technologies.....
Cost vs. Return on Investment
## UAV Platform Options and Specifications

<table>
<thead>
<tr>
<th>Description</th>
<th>Quad</th>
<th>Fixed Wing</th>
</tr>
</thead>
<tbody>
<tr>
<td>UAV</td>
<td>$6,500.00</td>
<td>$7,500.00</td>
</tr>
<tr>
<td>UAV Upgrades</td>
<td>$2,000.00</td>
<td>$3,000.00</td>
</tr>
<tr>
<td>NIR Camera</td>
<td>$7,000.00</td>
<td>$7,000.00</td>
</tr>
<tr>
<td>Software</td>
<td>$10,000.00</td>
<td>$10,000.00</td>
</tr>
<tr>
<td>GIS</td>
<td>$5,000.00</td>
<td>$5,000.00</td>
</tr>
<tr>
<td><strong>Sub Total:</strong></td>
<td><strong>$30,500.00</strong></td>
<td><strong>$32,500.00</strong></td>
</tr>
<tr>
<td>Computer for Processing</td>
<td>$5,000.00</td>
<td>$20,000.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$35,500.00</strong></td>
<td><strong>$52,500.00</strong></td>
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</table>

<table>
<thead>
<tr>
<th>Feature</th>
<th>Quad</th>
<th>Fixed Wing</th>
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</thead>
<tbody>
<tr>
<td>Pilot</td>
<td>20-40 / hr.</td>
<td>20-40 / hr.</td>
</tr>
<tr>
<td>Spotter</td>
<td>10-20 / hr.</td>
<td>10-20 / hr.</td>
</tr>
<tr>
<td>Fuel Source</td>
<td>Battery</td>
<td>Battery</td>
</tr>
<tr>
<td>Flight Time</td>
<td>12 min</td>
<td>45 min</td>
</tr>
<tr>
<td>Acres per Flight</td>
<td>60</td>
<td>300</td>
</tr>
<tr>
<td>Setup / Breakdown</td>
<td>10 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Processing Time (160ac)</td>
<td>2hr</td>
<td>20 min</td>
</tr>
<tr>
<td>Resolution</td>
<td>3 cm</td>
<td>5 cm</td>
</tr>
</tbody>
</table>
Soil, UAV, and Real-time Sensor Integration
Average Cost / Acre

<table>
<thead>
<tr>
<th></th>
<th>Existing System</th>
<th>VRI</th>
<th>Annually</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Avg. Conventional Design</td>
<td>Avg. VRI Design</td>
<td>Development Difference</td>
</tr>
<tr>
<td>Phases 1-3</td>
<td>$ 70.00</td>
<td>$ 105.00</td>
<td>$ 35.00</td>
</tr>
<tr>
<td>Installed Drip System</td>
<td>$ 750.00</td>
<td>$ 983.00</td>
<td>$ 233.00</td>
</tr>
<tr>
<td>Automation</td>
<td>$ 200.00</td>
<td>$ 200.00</td>
<td>$ -</td>
</tr>
<tr>
<td>Soil Moisture Sensors</td>
<td>$ 40.00</td>
<td>$ 60.00</td>
<td>$ 20.00</td>
</tr>
<tr>
<td>Scheduling</td>
<td>$ 40.00</td>
<td>$ 40.00</td>
<td>$ -</td>
</tr>
<tr>
<td>UAV Imagery</td>
<td>$ 30.00</td>
<td>$ 30.00</td>
<td>$ -</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$ 1,130.00</td>
<td>$ 1,418.00</td>
<td>$ 288.00</td>
</tr>
</tbody>
</table>
Almonds ROI <1 year

<table>
<thead>
<tr>
<th>Description</th>
<th>Avg.</th>
<th>Unit Cost</th>
<th># of Units</th>
<th>Total Cost</th>
<th>Year 1 Return/ Ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Savings (acre feet)</td>
<td>28.7%</td>
<td>$115.00</td>
<td>4.2</td>
<td>$483.00</td>
<td>$138.62</td>
</tr>
<tr>
<td>Fertilizer and Amendment Savings</td>
<td>17.8%</td>
<td>$150.00</td>
<td>1</td>
<td>$150.00</td>
<td>$26.70</td>
</tr>
<tr>
<td>Power Savings (.10KwH at 500ft)</td>
<td>28.7%</td>
<td>$68.50</td>
<td>4.2</td>
<td>$-</td>
<td>$82.57</td>
</tr>
<tr>
<td>Almond increased Turnout</td>
<td>6.2%</td>
<td>$4.50</td>
<td>3200</td>
<td>$-</td>
<td>$892.80</td>
</tr>
<tr>
<td>Avg. Sensor Integration ROI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$1,140.69</td>
</tr>
</tbody>
</table>

Increased shake out - remove more nuts from heavier areas increased turnout
Reduced hull rot from humidity in heavier soil profiles increased turnout
# Table Grapes ROI 1.2 years

<table>
<thead>
<tr>
<th>Description</th>
<th>Avg.</th>
<th>Unit Cost</th>
<th># of Units</th>
<th>Total Cost</th>
<th>Year 1 Return/Ac</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Savings (acre feet)</strong></td>
<td>29.9%</td>
<td>$115.00</td>
<td>3.2</td>
<td>$368.00</td>
<td>$110.03</td>
</tr>
<tr>
<td><strong>Fertilizer and Amendment Savings</strong></td>
<td>22.1%</td>
<td>$230.00</td>
<td>1</td>
<td>$230.00</td>
<td>$50.83</td>
</tr>
<tr>
<td><strong>Power Savings (.10kWh at 500ft)</strong></td>
<td>29.9%</td>
<td>$41.10</td>
<td>4.2</td>
<td>-</td>
<td>$51.61</td>
</tr>
<tr>
<td><strong>Table Grapes increased Packout</strong></td>
<td>13.1%</td>
<td>$14.50</td>
<td>1600</td>
<td>-</td>
<td>$3,039.20</td>
</tr>
<tr>
<td><strong>Avg. Sensor Integration ROI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$3,251.68</td>
</tr>
</tbody>
</table>

Reduced softness in heavy areas due to saturation increases pack out
Increased maturity, color and sugar content in heavier soil profiles increases pack out
Reduced soft fruit in light soils due to limited available water increases pack out
Northwest Information Resources

- Bonneville Power Website
  http://www.bpa.gov/EE/Sectors/agriculture/Pages/default.aspx
  E3TNW database of emerging technologies: www.E3TNW.org

- NEEA reports
  http://neea.org/resource-center/market-research-and-evaluation-reports?topic=df3216e1-8961-4ac1-adbc-4f174e926f50&sort=PublicationDate+DESC

- WSU Irrigation Scheduler
  http://weather.wsu.edu/is/
  USBR Agrimet
  http://www.usbr.gov/pn/agrimet/
CEC Water Energy Tech (WET) Programs

Water Energy Technology (WET) Program
  – Funding of **commercially available** technologies
  – Funding not addressed in the 2014-2015 legislative session
  – Program Launch suspended until funds are available

EPIC (Electric) and PIER (Natural Gas) Programs
  – R&D funding for **pre-commercial** water and energy saving technologies and strategies
  – Funding periodically available
    • Electric Program Investment Charge (EPIC) Funding Opportunities:
      [http://www.energy.ca.gov/contracts/epic.html](http://www.energy.ca.gov/contracts/epic.html)
    • Natural Gas R&D Funding Opportunities:
      [http://www.energy.ca.gov/contracts/pier.html](http://www.energy.ca.gov/contracts/pier.html)

Contact: Heather Bird at heather.bird@energy.ca.gov
California Information Resources

UC Davis Center for Water-Energy Efficiency: http://cwee.ucdavis.edu

Center for Irrigation Technology at Fresno State University: https://www.fresnostate.edu/jcast/cit/

California Polytechnic State University (Cal Poly) San Luis Obispo’s Irrigation Training and Research Center: http://www.itrc.org/
California Information Resources

California Department of Food and Agriculture’s State Water Efficiency and Enhancement Program (SWEEP): http://www.cdfa.ca.gov/environmentalstewardship/weep.html

Central Plains Irrigation Association: http://www.centralplainsirrigationassociation.org/

H2O Optimizer: http://www.h2o-optimizer.com

Colorado State University Industrial Assessment Center: http://projects-web.engr.colostate.edu/IAC/
Questions?

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Upcoming Showcase Webinars

October 22 – Easily Commissioned Lighting Controls
TBD – Mogul Base LED Lamps for Retrofits

Information and registration at [www.e3tnw.org/webinars](http://www.e3tnw.org/webinars)

Join our email list for notification at [subscribe-e3tnw@listserv.energy.wsu.edu](mailto:subscribe-e3tnw@listserv.energy.wsu.edu)

More information about emerging technologies:
- E3T database: [www.e3tnw.org](http://www.e3tnw.org)
- E3T Program: [www.bpa.gov/energy/n/emerging_technology/](http://www.bpa.gov/energy/n/emerging_technology/)
- Conduit: [www.ConduitNW.org](http://www.ConduitNW.org)

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