MEMO

To: Ben Wade, CWCB
From: Jorge Figueroa, Western Resource Advocates
RE: 50% Completion Report -- Water Efficiency Grant - POGGI PDAA 20170000000000000521
"Best-practices and Technical Guidelines for High-Performance, Comprehensive, Water Efficiency Retrofit Projects"
Date: March 28, 2017

This memo provides a 50% completion report on WRA's progress to date for the grant "Best-practices and Technical Guidelines for High-Performance, Comprehensive, Water Efficiency Retrofit Projects" (PO#: POGGI PDAA 20170000000000000521). As stated in our proposal, this report includes:

(i) List of Advisory Committee members
(ii) Summary of measurement and verification (M&V), and commissioning protocol development
(iii) Draft best-practices and technical guidelines for selected water measures

I. List of Advisory Committee members (now called "Steering Committee".)

Steering Commitee Members | Water, Measurement and Verification (M&V) Guidelines, State Performance Contracts Project		
Name	**Affiliation**	**Title**
Donald Gilligan	National Association of Energy Service Companies	President
Mary Ann Dickinson	Alliance for Water Efficiency	President and CEO
John Canfield	Trident Energy Services	President
Chris Halpin	Celtic Energy	President
Patrick Watson	Southern Nevada Water Authority	Conservation Services Administrator
Carlos Bustos	Albuquerque Bernalillo County Water Utility Authority	Water Conservation Program Manager
Frank Kinder	Colorado Springs Utilities	Senior Conservation Specialist
Paul Matuska	US Bureau of Reclamation	Manager, Water Accounting and Verification Group
William D. Taylor	Energy Services Coalition-Nevada Chapter	Private Sector Co-Chair
Oscar Rangel	Energy Services Coalition-Colorado Chapter	Private Sector Co-Chair
Scott Griffith	Energy Services Coalition-New Mexico Chapter	Private Sector Co-Chair
Harold Trujillo	New Mexico Energy Technology and Engineering Bureau New Mexico EPC Program	Chief
Kelly Thomas	Nevada Governor's Office of Energy Nevada EPC Program	Energy Program Manager
Taylor Lewis	Colorado Energy Office Colorado EPC Program	Program Engineer

II. Summary of the Measurement and Verification (M&V), and commissioning protocol development.

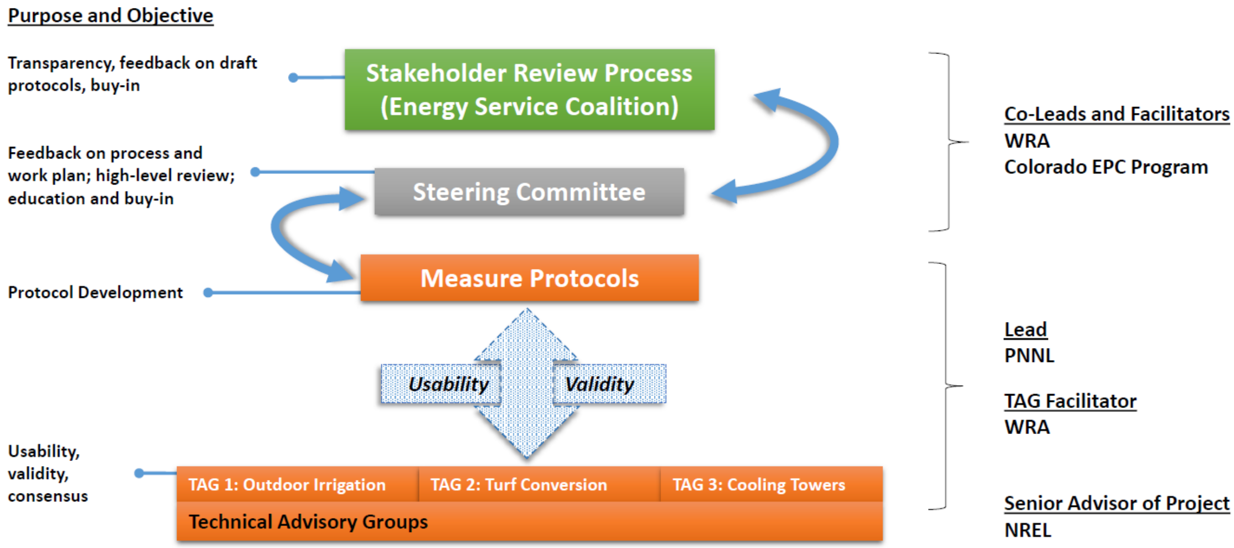
A. *Key recommendations from Steering Committee.* The Steering Committee had its kick-off meeting on March 6, 2017. In its first meeting, the Steering Committee approved the methodology, selected water measures, and timeline (see B-D below).

B. *Methodology*. WRA and the Colorado Energy Office (CEO) have adopted the framework of the Uniform Methods Project (UMP) for the development of the M&V and commissioning protocol guidelines.

The UMP, developed by the National Renewable Energy Lab (NREL), has been used to evaluate *energy savings* for residential, commercial, and industrial measures commonly offered in ratepayer-funded programs in the United Sates. Although NREL has developed 23 protocol guidelines under the UMP, this is the first time that the UMP framework will be used to develop M&V protocol guidelines for water measures. The protocol guidelines will be based on a particular International Performance Verification and Measurement Protocol (IPMVP) option, but will add detail.

The Co-Leads and facilitators of the project are WRA and the Colorado Energy Office. The Technical Lead for the development of the M&V protocol guidelines is the Pacific Northwest National Lab (PNNL). The UMP framework is a transparent and systematic peer-review and buy-in process that relies heavily on the review and input of subject matter and industry experts and the broader performance contracting stakeholder community (see Figure 1).

Figure 1. Project organization and methodology.

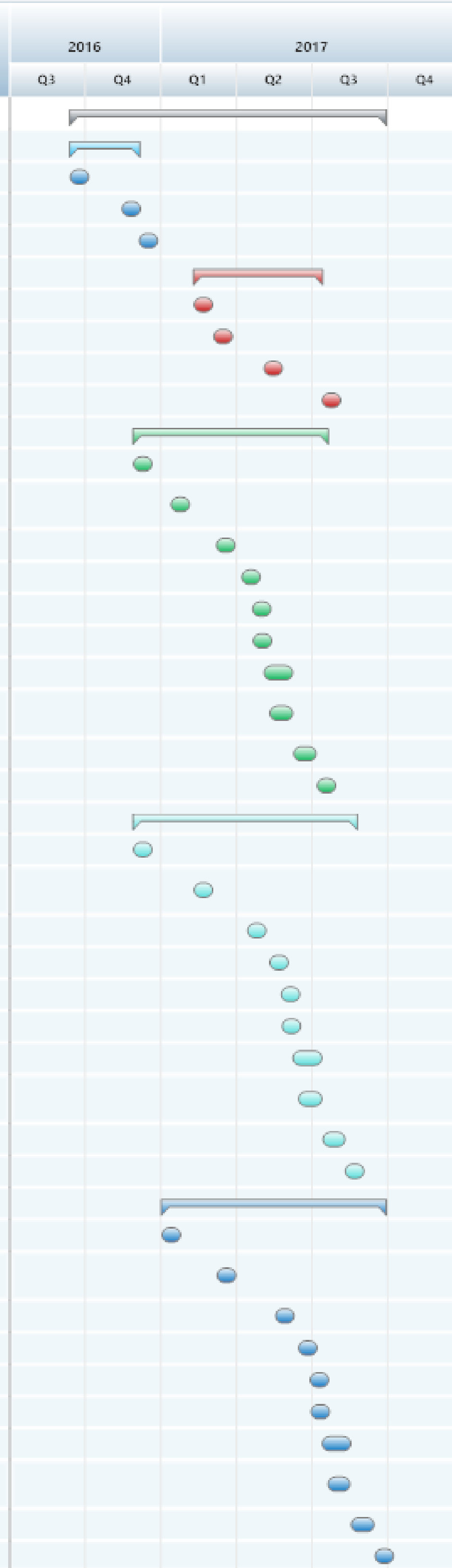


C. *Selected Water Measures for the Project.* Based on Statewide Water Supply Initiative (SWSI) assessments on the conservation potential of specific water measures and input from key Colorado water conservation experts, Western Resource Advocates (WRA) selected the following three measures that the project will cover:

- Outdoor irrigation upgrades
- Turf conversion
- Cooling tower retrofits

D. *Detailed protocol development timeline.*

	Task	Start	End
	Public Buildings Project	9/12/16	9/28/17
1	PROJECT SCOPING	9/12/16	12/5/16
1.1	WRA-CEO Meeting	9/12/16	9/12/16
1.2	Kick-Off Meeting	11/14/16	11/14/16
1.3	Final Meeting	12/5/16	12/5/16
2	STEERING COMMITTEE	2/10/17	7/13/17
2.1	SC Convened	2/10/17	2/10/17
2.2	SC Meeting 1	3/6/17	3/6/17
2.3	SC Meeting 2	5/4/17	5/4/17
2.4	SC Meeting 3	7/13/17	7/13/17
3	TAG1-OUTDOOR IRRIGATION	11/28/16	7/20/17
3.1	OI Best Practices Lit Review	11/28/16	12/13/16
3.2	OI Best Practices and M&V Outlines shared (internal)	1/13/17	1/13/17
3.3	TAG1 Convened	3/9/17	3/9/17
3.4	TAG1 receives preliminary draft	4/7/17	4/7/17
3.5	TAG1 Meeting	4/20/17	4/20/17
3.6	OI Draft Protocols v.1	4/21/17	5/4/17
3.7	OI Steering Committee Review	5/4/17	6/8/17
3.8	OI Stakeholders Review/Comment	5/11/17	6/8/17
3.9	OI Responses and Edits	6/9/17	7/6/17
3.10	OI Final Draft Protocols	7/7/17	7/20/17
4	TAG2-TURF CONVERSION	11/28/16	8/24/17
4.1	TC Best Practices Lit Review	11/28/16	12/13/16
4.2	TC Best Practices and M&V Outlines shared (internal)	2/10/17	2/10/17
4.3	TAG2 Convened	4/14/17	5/1/17
4.4	TAG2 receives preliminary draft	5/11/17	5/11/17
4.5	TAG2 Meeting	5/25/17	5/25/17
4.6	TC Draft Protocols v.1	5/26/17	6/8/17
4.7	TC Steering Committee Review	6/8/17	7/13/17
4.8	TC Stakeholders Review/Comment	6/15/17	7/13/17
4.9	TC Responses and Edits	7/14/17	8/10/17
4.10	TC Final Draft Protocols	8/10/17	8/24/17
5	TAG3-COOLING TOWERS	1/2/17	9/28/17
5.1	CT Best Practices Lit Review	1/2/17	1/17/17
5.2	CT Best Practices and M&V Outlines shared (internal)	3/10/17	3/10/17
5.3	TAG3 Convened	5/18/17	5/18/17
5.4	TAG3 receives preliminary draft	6/15/17	6/15/17
5.5	TAG3 Meeting	6/29/17	6/29/17
5.6	CT Draft Protocols v.1	6/30/17	7/13/17
5.7	CT Steering Committee Review	7/13/17	8/17/17
5.8	CT Stakeholders Review/Comment	7/20/17	8/16/17
5.9	CT Responses and Edits	8/17/17	9/14/17
5.10	CT Final Draft Protocols	9/15/17	9/28/17



III. Draft best-practices and technical guidelines for selected water measures.

At the final project scoping meeting on December 5, 2016, the project team chose to adopt a timeline in which the protocols will be staggered a month apart, rather than all at once (see II.D).
Because the adopted protocol production schedule was developed with the main contractor *after* the CWCB grant was submitted, the production timeline for the draft best practices and protocols has changed from the original proposal.

As per the timeline, the draft protocols and draft best practices for outdoor irrigation will be completed in April, and the ones for turf conversion and cooling towers in May and June, respectively. Accordingly, we expect to submit the draft protocols and draft best practices of the three measures to the CWCB with the 75% completion progress report by the end of June, 2017.

The following appendices are included with this progress report:

- Appendix A: Outdoor Irrigation M&V and Commission Protocols Outline
- Appendix B: Turf Conversion M&V and Commission Protocols Outline
- Appendix C: Cooling Towers M&V and Commission Protocols Outline
- Appendix D: Outdoor Irrigation and Turf Conversion Best Practices Outline
- Appendix E: Cooling Towers Best Practices Outline

IV. Summary and Next Steps.

The project is on schedule, with excellent support from the Colorado Energy Office as the project's co-Lead, with the Pacific Northwest National Laboratory as our main contractor. A high-caliber Steering Committee has been convened, with strong representation from key water utilities, state agencies, and the private sector. A clearly defined, well-tested and transparent protocol development process has been adopted for 3 high-impact water conservation measures identified by SWSI for the municipal sector. With the best practices outlines and M&V protocol outlines completed for each of the three water measures, the project is ready to move into the formal technical protocol development work that will occur between the months of April and September of 2017.

Appendix A

Outline | Outdoor Irrigation M&V Protocol

Measure Description

- General description of the measure
- Types of projects implemented as part of this measure
  - Irrigation system efficiency improvements:
    - repair and reconfiguration of system to improve system efficiency
    - conversion to water efficient systems such as drip or micro-spray system
  - Controls upgrade:
    - weather-based controller
    - soil moisture-based controller
    - central irrigation control system
  - Real-time sensors:
    - rain-sensing technology
    - wind-sensing technology
    - freeze-sensing technology

Savings Calculations

Water Use Savings = (Baseline Water use – Post-Installation Water Use) ± Adjustments

- Baseline Water Use = irrigation water use of the existing system
- Post-Installation Water Use = irrigation water use after implementation of irrigation improvements
- Adjustments = normalized to historic evapotranspiration (ET) (inches per year)

Baseline Water Use Determination Options

- Meter:
  - Existing metered data
  - Spot metering to determine system flow rates and multiply by system run-time
- Irrigation audit: determine precipitation rate of the system (inches per hour) and multiply by the system run-time and landscape area
- Water use to be normalized to historic ET

Post-installation Water Use Determination

- Meter installed as part of the efficiency measure:
  - Metered data collected during performance period
    - Continuous measurement
    - Short-term/spot measurement
  - Water use normalized to historic ET

Measurement and Verification Plan

Measurement and Verification Method

IPMVP method – Option B: Savings should be determined by field measurement of the water use and parameters that effect irrigation system

Data Collection

- Measurement boundary – irrigation system
- Measurement period and frequency
    - Continuous measurement
    - Short-term/spot measurement
- Irrigation audit
    - Precipitation rate
    - Distribution uniformity
    - System efficiency
- Measurement equipment
    - Meter options

Detailed Procedures

- Description on how to calculate irrigation water savings using:
    - Continuous measurement
    - Short-term/spot measurement
    - Irrigation audit

Data Normalization

- Best practice method on how to normalize the data to historic ET

Other Evaluation Issues

Description of issues that may impact measure such as savings as a result of watering restrictions

Commissioning Protocols

A general description of commissioning protocols including:

- Commissioning strategies: Irrigation Association's Irrigation System Inspection and Commissioning Guidelines
- Required tests to ensure that equipment meets the design specifications
    - Flow rate tests
    - Pressure tests
    - Leak tests

References

Appendix B

Outline | Turf Conversion M&V Protocol

Measure Description

- General description of the measure:
    - Removal of turf with replacement of native/adaptive plants and/or artificial turf
    - Installation of new/reconfigured irrigation system

Savings Calculations

Water Use Savings = (Baseline Water use – Post-Installation Water Use) ± Adjustments

- Baseline Water Use = irrigation water use of the existing system
- Post-Installation Water Use = irrigation water use after implementation of turf conversion project
- Adjustments = normalized to historic evapotranspiration (ET) (inches per year)

Baseline Water Use Determination Options

The following options will be provided for estimating baseline water use, listed in order of accuracy:

- Existing dedicated metered data that provides volume of water used over the study period
- Spot metering to determine system flow rates by zone, multiplied by zone run-time
- Irrigation audit (using Irrigation Association audit protocols) to determine precipitation rate of the system (inches per hour) by zone, multiplied by the zone run-time and landscape area
- Calibrated modeled to estimate water use using historic weather data (ET and precipitation) and landscape parameters

Baseline water use will be normalized to historic ET only if there is a weather-based control system or weather sensors (e.g., rain-sensing equipment) in place, or irrigation schedule is routinely monitored and adjusted for changes in weather.

Post-installation Water Use Determination

A meter will be installed as part of the efficiency measure that will be used to track water use over the performance period using:

- Continuous measurement using in-line meter or flow sensors tied to a centralized control system.
- Short-term monitoring with temporary meter or in-line meter that will monitor flow rate

Post-installation water use will be normalized to historic ET.

Measurement and Verification Plan

Measurement and Verification Method

Recommended IPMVP method – Option B: Savings should be determined by field measurement of the water use

Data Collection

- Measurement boundary – landscape area
- Measurement period and frequency
  - Continuous measurement: Data should be collected to capture full irrigation season
  - Short-term/spot measurement: Data should be collected periodically during the irrigation season to capture savings through shoulder months and peak irrigation months
- Irrigation audit for baseline water use calculation
- Measurement equipment
  - Meter options

Detailed Procedures

- Description on how to calculate irrigation water savings using:
  - Continuous measurement
  - Short-term/spot measurement
  - Irrigation audit for baseline water use: a general description will be provided on the following data points that will be collected from an irrigation audit:
    - Precipitation rate
    - Distribution uniformity
  - Calibrated modeled to estimate water use using historic weather data

Data Normalization

- Best practice method on how to normalize irrigation water use to historic ET

Other Evaluation Issues

Description of issues that may impact the measure such as savings as a result of watering restrictions

Commissioning Protocols

A general description of commissioning protocols including:

- Commissioning strategies of new native/adaptive landscaping:
  - Documentation of plants installed and verification that landscape plan was followed
  - After designated timeframe, verification that plants are healthy and roots have been established
- Commissioning strategies of new irrigation system (if applicable): Irrigation Association's Irrigation System Inspection and Commissioning Guidelines
  - Irrigation audit to determine:

        - Precipitation rate
        - Distribution uniformity
        - System efficiency
- Required tests to ensure that equipment meets the design specifications
    - Flow rate tests
    - Pressure tests
    - Leak tests

References

Appendix C

Outline | Cooling Tower M&V Protocol

Measure Description

- General description of the measure
- Types of projects implemented as part of this measure
    - Cooling tower system efficiency improvements:
        - ensure mechanical components are all working properly and in good condition
        - maximize cycles of concentration
    - Controls upgrade:
        - conductivity controller
    - Real-time sensors:
        - conductivity/blowdown
        - chemical treatment residuals
        - corrosion rates
        - pH

Savings Calculations

Water Use Savings = (Baseline Water use – Post-Measure Installation Water Use) ± Adjustments

- Baseline Water Use = cooling tower water use of the existing system
- Post-Installation Water Use = cooling tower water use after improvements
- Adjustments = normalized to historic weather data

Baseline Water Use Determination Options

The following options for estimating baseline water use will be provided, listed in order of accuracy:

- Metered data (either permanent or temporary) that measures water use during the study period
- Engineering estimate based on chiller nameplate tonnage, hours of operation, and cycles of concentration

Baseline water use will be normalized to typical meteorological year (TMY) historic weather data.

Post-Measure Installation Water Use Determination

A meter will be installed as part of the efficiency measure that will be used to track water use over the performance period using:

- Continuous measurement using an in-line meter or flow sensors tied to a centralized control system or a data logger, which continuously records water use data over the study period
- Short-term monitoring with a temporary meter or in-line meter that will monitor flow rate

Post-installation water use will be normalized to TMY history weather data.

Measurement and Verification Plan

Measurement and Verification Method

Recommended IPMVP method – Option B: Savings should be determined by field measurement of the water use and parameters that effect the cooling tower system

Data Collection

- Measurement boundary – cooling tower system
- Measurement period and frequency
    - Continuous measurement: Data should be collected to capture full cooling season
    - Short-term/spot measurement: Data should be collected periodically during the peak cooling season to capture savings through shoulder months
    - Engineering estimate: Cycles of concentration should be determined periodically during the cooling season
- Measurement equipment
    - Meter options

Detailed Procedures

- Description on how to calculate cooling tower water savings using:
    - Continuous measurement
    - Short-term/spot measurement
    - Engineering estimate for water use using chiller tonnage, hours of operation, and cycles of concentration

Data Normalization

- Best practice method on how to normalize the data to TMY historic weather data

Other Evaluation Issues

Description of issues that may impact measure such as evaporation credits

Commissioning Protocols

A general description of commissioning protocols including:

- Commissioning strategies: Follow performance testing according to the Cooling Technology Institute standards (Information on these standards can be found at www.cti.org)
- Required tests to ensure that equipment meets the design specifications

References

Appendix D
Outline | Outdoor Irrigation and Turf Conversion Best Practices for State Performance Contracts in Colorado

Outline | Best Practices recommended for public sector clients

ESCO Selection

- Include outdoor irrigation improvements/turf conversion as wish-list, default items
- Require the ESCOs' responses to the Request for Proposal to include:
  - A description of the personnel responsible for outdoor irrigation/turf conversion and their qualifications. Look for certification from Irrigation Association, CWEP, Water Smart or other quality certification programs.
  - The ESCO's approach to developing water baselines and the measurement & verification (M&V) approach for outdoor irrigation/turf conversion for the project (if applicable).

Pre-Contract

- Ensure that the risks and responsibilities of the client and the ESCO, and the proposed M&V approach for outdoor irrigation/turf conversion are carefully reviewed and points for discussion are noted. (Otherwise, the assumptions used will generally carry through to the Investment-Grade Audit.)

Investment Grade Audit

- Be prepared to facilitate site access and make available needed outdoor landscape managers and experts for multiple visits by the ESCO.

Designated Person

- To avoid miscommunication and maintain consistency, designate an individual to serve as the conduit of outdoor irrigation/turf conversion information between the ESCO and agency.
- Develop a review plan and set aside focused review time. Assign overall review of the outdoor irrigation/turf conversion components of the IGA/proposal and specific sections, respectively, to the designated individual.
- Documentation of project development and communication between the client and the ESCO should be included in contract files. Include all pre-award communications such as Preliminary Assessment (PA) and Investment Grade Audit (IGA) development notes, proposal questions, responses, and resolutions, and other direction and agreements related to the outdoor irrigation/turf conversion plan and maintenance.

Critical Outcomes of Review

The client will need to verify before proceeding to award, that:

- The proposed water consumption baselines and fixed parameters for calculating water savings are sound.
- The guaranteed savings from water measures are reasonable, given analysis of assumptions and savings received on similar projects.

Training and Technical Support

- Request information about best practices related to landscape irrigation/turf conversion to the state EPC Program.
- Request training for outdoor irrigation retrofits (irrigation system management and maintenance). The ESCO may arrange on-site training, and training for new project team members.

Outline | Best Practices recommended for the State of Colorado's EPC Program
(for internal discussion)

- The State EPC program should provide information about best practices related to landscape irrigation/turf conversion to the client:
    - Landing page with general outdoor irrigation and turf conversion BMP categories (with small paragraph describing each category)
    - A copy of and/or link to the Irrigation Association & American Society of Irrigation Consultants' Landscape Irrigation Best Management Practices (2014) https://www.irrigation.org/uploadedFiles/Standards/BMPDesign-Install-Manage.3-18-14(2).pdf
- The state EPC program should recommend that ESCO staff involved in outdoor irrigation/turf conversion retrofits should have at least one of the following certifications:
    - Irrigation Association -- Certified Irrigation Professional
        - **Certified Landscape Irrigation Auditor**
        - **Certified Golf Irrigation Auditor**
        - **Certified Irrigation Contractor**
        - **Certified Irrigation Designer - Landscape**
    - Association of Energy Engineers -- Certified Water Efficiency Professional (CWEP)
- Training
    - The State EPC program should encourage ESCOs, where applicable, to offer training to outdoor landscape managers related to the management and maintenance of the outdoor irrigation retrofits installed.
    - State EPC program could also offer to host certification-related trainings (in partnership with CWCB/Irrigation Association/Association of Energy Engineers).

Outline | Best Practices recommended for public sector clients

Cooling Tower Operations (SAMPLE) Checklist

Optimal cooling tower operations can most successfully be achieved if the following steps are followed:

1. Determine makeup water quality – Obtain from your municipality or work with your water treatment vendor to determine makeup water quality. This will enable the establishment of target Cycles of Concentration (COC).

2. Establish target Cycles of Concentration (COC) – Based on makeup water quality, set a practical COC goal using the Target Cycles of Concentration.

3. Monitor COC and water performance frequently – Keeping the system running at peak COCs while staying within water performance levels will maximize efficiency and protect equipment.

4. Automate where possible - Utilize automated monitoring and alarms when available and cost effective. Implement direct chemical feeds at the makeup distribution. Enable BMS logging.

5. Protect the equipment – Adhere to all regular maintenance schedules. Utilize coupon racks, Eddy Current testing and other methods to ensure no corrosion, scale buildup or bio-fouling is occurring.

6. Engage your vendor – Work with your water treatment vendor to ensure the system is being maintained within all control limits and each step above is being performed.

7. Share your success

(From EDF's Cooling Tower Efficiency Guide Property Managers)

Outline | Best Practices recommended for the State of Colorado's EPC Program
(for internal discussion)

- The State EPC program should provide information about best practices related to cooling tower retrofits and operation and maintenance to the client:

  Landing page with general cooling tower BMP categories:

For example:

- **General Categories to Reduce Cooling Tower Water Consumption**
    - With small paragraph describing each category
    - With copy or link to reliable, well-recognized best practices
      i.e. FEMP's Cooling Tower BMPs, https://energy.gov/eere/femp/best-management-practice-10-cooling-tower-management;
      Association of Water Technologies (AWT) Cooling Tower Best Practices, http://www.awt.org/pub/03792B9C-FEC1-ADAC-729C-B976C970D1D2

Sample Categories

- **Address Tower Water Balance and Consumption**
  To optimize the water conservation of any cooling tower the entire water balance of the tower should be addressed. Water outflows (losses) include evaporation, bleed, overflows, drift, splash-out, windage and system leaks. Some water outflows are controlled (evaporation and bleed) and are essential to the correct operation of the tower and system. These controlled outflows need to be optimized. Some water outflows are uncontrolled (overflows, drift, splash out, windage, leaks and filter backwashing). Uncontrolled water outflows need to be minimized or removed.

- **Audit the Tower Water Balance**
  The water efficiency of a system needs to be optimized and the first step is to conduct a system water audit. The key water parameters are measured, recorded and system KPIs calculated. The water efficiency is calculated in accordance with the AIRAH Cooling Tower Water Efficiency Calculator (http://www.ctwec.com/) and reported.

- **Manage the Tower Operation**
  Regular monitoring of a cooling towers' normal water usage pattern will identify any peaks or irregularities in water consumption. Water meters need to be placed on the make-up water line and, where practical and economically feasible, the bleed water line to effectively understand the tower water consumption pattern. Suitable meters such as electromagnetic flow meters, which will not block or foul from particulate matter, should be used on bleed lines. Towers need to be regularly audited and their performance and condition assessed. Cooling towers and associated systems require regular maintenance and need to be periodically fine-tuned to ensure that they continue to match operational loads and are providing optimal performance. Water and energy use should be continually reviewed to ensure that the benefits of any system improvements or refinements are achieved. A well managed system, whether it is in an industrial or HVAC&R application, will generally reject more heat, use less power, consume less water and produce less risk than a poorly managed system.

- **Optimize Water Management**
  Water treatment systems should be optimized and reviewed for their effectiveness and operation. Water filters need to be maintained and their application reviewed with respect to contaminant challenges. Filter backwash and cleaning/maintenance water needs to be quantified and managed and any makeup and bleed filtration optimized.

- **Alternative Water Sources and Uses**
  Utilizing alternative water sources can significantly reduce the potable water consumption of the tower. In Colorado, depending on the specific location, use, and timing of the use of the site's water rights, bleed water and any water used for system cleaning and maintenance may be captured, reused and recycled to improve the overall water consumption of the facility.
- **Upgrades**
  Scheduled replacements and upgrades provide an opportunity to improve the performance and sustainability and reduce the water consumption of older cooling water systems.

Categories from the Australian Institute of Refrigeration, Air Conditioning, and Heating's *Water Conservation in Cooling Towers Best Practices Report,* http://www.airah.org.au/Content_Files/BestPracticeGuides/BPG_Cooling_Towers.pdf

- Cooling Tower related certifications (Cooling Technology Institute et al.?) The state EPC program could recommend that ESCO staff involved in cooling tower retrofits should have certified cooling tower professional?

- Training
  - The State EPC program should encourage ESCOs, where applicable, to offer training to building managers and/or staff related to the management, operation, and maintenance of the cooling tower retrofits installed.
  - State EPC program could also offer to host certification-related trainings (in partnership with CWCB/Association of Energy Engineers/CTI?).