TRM EUI Measure Development Project

GDS Associates, Inc.
ENGINEERS & CONSULTANTS

TRMAC Meeting

April 14, 2015

Meeting Goals

- Review Project Objectives
- Present Preliminary Measures
- Solicit Feedback
  - Are these measures going to be useful?
  - Can you help inform the final development?
  - Direction for complex measures
- Next Steps

Project Objectives

Identify a set of Electric Utility Infrastructure (EUI) measures to quantify energy efficiency savings

For each of these measures:

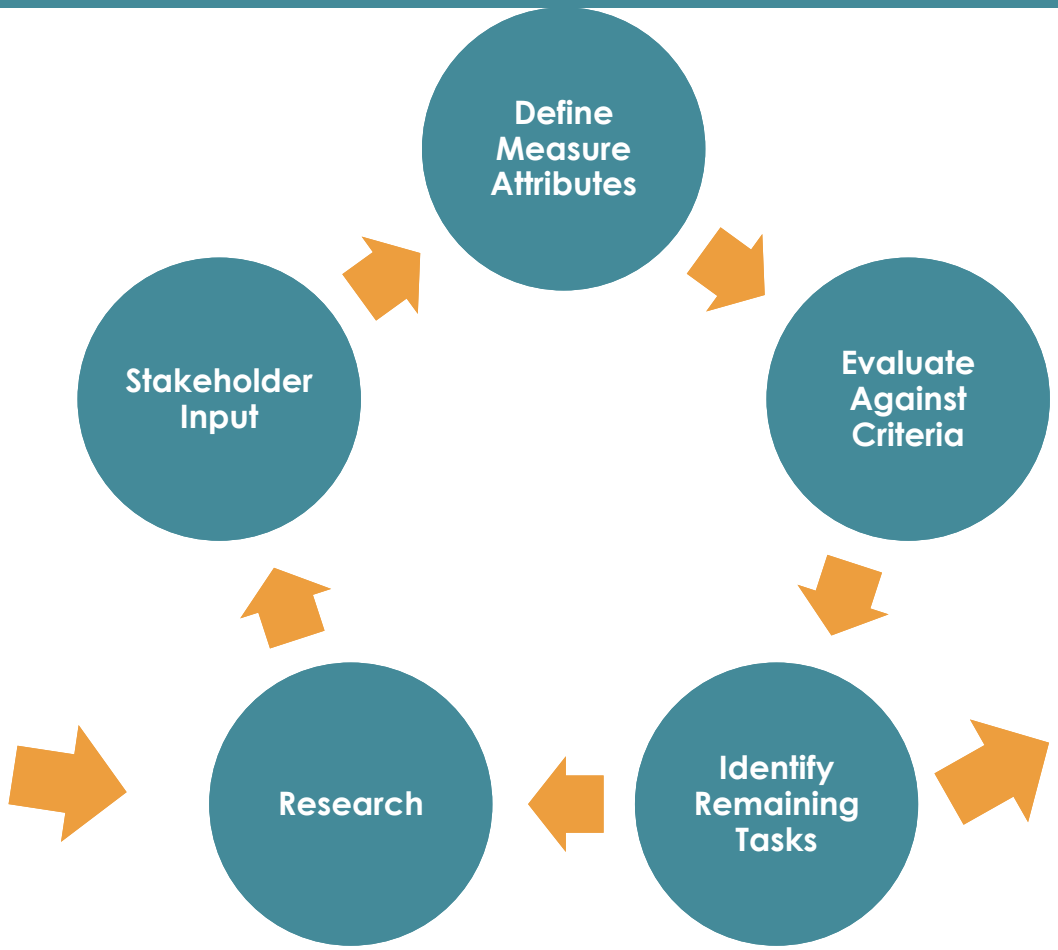
- Create savings algorithms for inclusion in the TRM
- Determine incremental cost to implement the measure
- Create a Smart Measure™ for stakeholders' use on ESP™
- Provide references for algorithms, assumptions, and values
- Recommend an ongoing measure update schedule

Project Methodology

List of Preliminary Measures

Stakeholder Input

Decide Which Measures are Worth Further Development



Fully Developed Measure Ready for TRM Inclusion

Measures Under Development

Transmission and Distribution

- Transmission Line Reconductoring
- High Efficiency Transmission and Distribution Transformers
- Voltage Conversion
- Automated Conservation Voltage Regulation
- Switched Capacitors

Generation

- General algorithm for heat rate improvements
- Steam Turbine Upgrades
- Steam Plant Upgrades
- Combustion Turbine Upgrades
- Parasitic Load Reductions

Other Measures

- LEDs
- VFDs
- Motors
- HVAC

Measures Under Development

Measures for Future Consideration

- Install storage
- Load Leveling
- CHP
- Plant Waste Heat Recovery
- Advanced Metering Infrastructure

Measures Under Development

Other Measures

Lighting, Motors, VFDs, etc.

Existing measures from the C/I section of the TRM will be reviewed for applicability to utility-owned facilities. Most valuable measures will be added, possibly with minor changes (Hrs, HVAC interactive effects, Coincidence Factors, etc), to Infrastructure section.

Measures Under Development

Transmission and Distribution Measures

- Transmission Line Reconductoring
- Voltage Conversion
- High Efficiency Distribution and Transmission Transformers
- Automated Conservation Voltage Regulation
- Switched Capacitors

Measures Under Development

Transmission and Distribution Measures –T-Line Reconductoring

$$\Delta\, kWh/yr = 3 \times {I_{peak}}^2 \times (R_{base} - R_{ee}) \times LF \times \frac{8{,}760}{1{,}000}$$

$$\Delta kW_{Peak} = \frac{3}{1{,}000} \times {I_{peak}}^2 \times (R_{base} - R_{ee})$$

I_{peak} = Peak current (Amperes)

R = Conductor Resistance for a three phase configuration, found in standard references like the *Aluminum Electrical Conductor Handbook* (Ohms)

LF = loss factor, ratio of average losses to peak losses (%) From historical data

Measures Under Development

Transmission and Distribution Measures – T-Line Reconductoring

Example

I_{peak} = 115 Amperes
R_{base} = 0.706 Ohms (one mile of three phase 2/0 ACSR Conductor)
R_{ee} = 0.560 Ohms (one mile of three phase 3/0 ACSR Conductor)
LF = 30 %

$$\Delta\, kWh/yr = 3 \times (115\text{A})^2 \times (0.706\ \text{Ohms} - 0.560\ \text{Ohms}) \times 0.30 \times \frac{8{,}760}{1{,}000}$$

$$\boldsymbol{\Delta\, kWh/yr} = \textbf{15,222.8 kWh/yr per mile}$$

$$\Delta kW_{Peak} = \frac{3}{1{,}000} \times (115\text{A})^2 \times (0.706\ \text{Ohms} - 0.560\ \text{Ohms})$$

$$\boldsymbol{\Delta kW_{Peak}} = \textbf{5.79 kW per mile}$$

Measures Under Development

Transmission and Distribution Measures – Voltage Conversion

$$\Delta\, kWh/yr = \left[LL_{base} - \left(\left(\frac{kV_{base}}{kV_{ee}} \right)^2 \times LL_{base} \right) \right] \times LF \times 8{,}760$$

kV_{base} = Voltage of base lines (kV)
kV_{ee} = Voltage of higher voltage, efficient lines (kV)
LL_{base} = Line Loss at peak load for original, lower-voltage system (kW)
Can be calculated using I_{peak} value and the Conductor Resistance found in the T-lines measure
LF = loss factor, ratio of average losses to peak losses (%)

Measures Under Development

Transmission and Distribution Measures – High Efficiency Transformers

$$\Delta\, kWh/yr = 8{,}760 \times \left(\left[\left(\frac{Load_{Peak}}{FLC_{base}} \right)^2 \times FLL_{base} \times LF \; + \; NLL_{base} \right] - \left[\left(\frac{Load_{Peak}}{FLC_{ee}} \right)^2 \times FLL_{ee} \times LF \; + \; NLL_{ee} \right] \right)$$

$Load_{Peak}$ = Load during peak period (kVA)
FLC = transformer rated full-load capacity (kVA)
FLL = full-load losses, transformer winding kW loss at rated load (kW)
LF = loss factor, ratio of average losses to peak losses (%)
NLL = no-load losses (kW)

Measures Under Development

Transmission and Distribution Measures – Switched Capacitors

Measure savings algorithm still under development

Measures Under Development

Transmission and Distribution Measures – Automated CVR

$$\Delta\, kWh/yr = \sum_{i} kWh_{pre,i} \times \frac{\mathrm{CVR_{f,i}} \times \mathrm{V_{r,i}}\%}{(1 - \mathrm{CVR_{f,i}} \times \mathrm{V_{r,i}}\%)}$$

$\mathrm{CVR_{f,i}}$ = Conservation Voltage Reduction Factor calculated for period i

$kWh_{pre,i}$ = Energy delivered by feeder during period i

$\mathrm{V_{r,i}}\%$ = Average voltage reduction at end of line during period i

i defines each period of the year. For example, weekends and weekdays. Can be broken into many or few periods

Measures Under Development

Transmission and Distribution Measures – Automated CVR

$$\Delta\, kWh/yr = \sum_{i} kWh_{pre,i} \times \frac{\mathrm{CVR_{f\ i}} \times \mathrm{V_{r\ i}}\%}{(1 - \mathrm{CVR_{f\ i}} \times \mathrm{V_{r\ i}}\%)}$$

Stakeholder feedback: how detailed would you like the measure to be? Determining value for CVR_f and V_r requires some testing and modeling.

Higher accuracy will deliver greater savings, but will require more complicated modeling.

Prescribed CVR_f and V_r values will reduce modeling requirements, but lower savings potential

Measures Under Development

Generation Measures

Any project that improves the Heat Rate of a generation facility

Major Categories:

- Combustion Turbine Upgrades
- Steam Turbine Upgrades
- Steam Plant Improvements
- VFDs, LEDs, and other parasitic load improvements done as part of a complete plant overhaul

Measures Under Development

Generation Measures, General Savings Algorithm

$$\Delta\, kWh/yr = \left[\frac{(HR_0 - HR_1)}{\mathrm{HR}_0} \times \mathrm{kW}_0 \times LF \times Hours\right] + \left[\frac{(HR_0 - HR_1)}{HR_1} \times (kW_1 - kW_0) \times LF \times Hours\right]$$

Where:
HR is heat rate, LF is load factor, Hours is annual plant runtime, kW is plant capacity

Term in green brackets corresponds to improvements that result in lower required input Btu to deliver the same output kW capacity

Term in blue brackets corresponds to improvements that increase the plant kW capacity without increasing input Btu

Measures Under Development

Generation Measures, How to use Algorithm

$$\Delta\, kWh/yr = \left[\frac{kW_0}{HR_0} + \frac{(kW_1 - kW_0)}{HR_1}\right] \times (HR_0 - HR_1) \times LF \times Hours$$

For projects that ONLY result in parasitic load improvements (LEDs, VFDs, etc), use Other Measures to calculate savings

Use historical data to determine values for HR_0, kW_0, LF, and Hours.

For HR_1 and kW_1 - Projects must have a defensible projection from a utility or vendor modeling tool with documented and justifiable inputs.

Measures Under Development

Generation Measures – Question for Stakeholders

Two ways to handle savings calculations:

1) Produce a table of conservative, but risk-free assumptions for expected heat rate improvements that should be used for specific projects (example next slide).

Pro: no risk and no justification required. Con: lower savings

2) Use actual projected heat rate improvement on a project basis. More of a defined protocol rather than a prescriptive measure.

Pro: Greater savings and more accurate savings. Con: Requires utilities to model, report, and justify heat rate improvement estimates for generation projects.

Measures Under Development

Generation Measures – Table Example

Measure	$\frac{(HR_0 - HR_1)}{HR_0}$	$\frac{(HR_0 - HR_1)}{HR_1}$
Replace Superheater	1.9%	2.1%
Replace Turbine Blade	1.1%	1.2%
Implement Zonal Monitoring	0.1%	0.2%
Modify Heat Transfer Surface	0.5%	0.6%
Advanced Cooling Tower Packing	0.3%	0.35%

Measures Under Development

Generation Measures, General Savings Algorithm

$$\Delta\, kWh/yr$$
$$= \left[\frac{(HR_0 - HR_1)}{\mathrm{HR}_0} \times \mathrm{kW}_0 \times LF \times Hours\right]$$
$$+ \left[\frac{(HR_0 - HR_1)}{HR_1} \times (kW_1 - kW_0) \times LF \times Hours\right]$$

Where:
Red are variables we expect the utility to know.
Blue and green variables are under discussion.

Next Steps

Complete measure development for current measures

- Complete eligibility requirements
- Define incremental costs
- Add maintenance adjustment factors to baseline
- Develop Smart Measures

Continue Working with Stakeholders

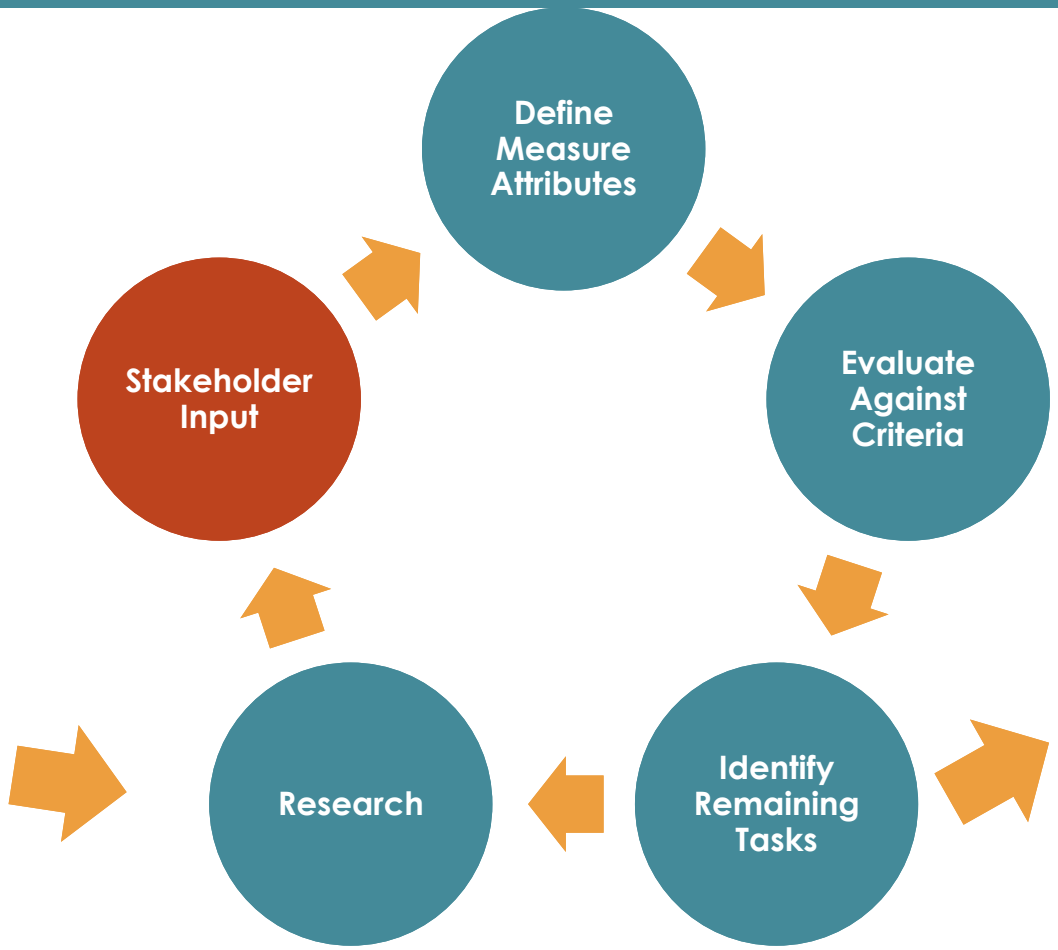
- Feedback on current measures under development

Stakeholder Feedback

List of Preliminary Measures

Stakeholder Input

Decide a Measures are Worth Further Development



Fully Developed Measure Ready for TRM Inclusion

Stakeholder Feedback

More Input Ensures More Valuable Final Measures

- Questions for GDS
- General direction of the project
- Are we focusing on valuable measures?
- Are the required savings calculation inputs going to be reasonable to produce?
- Generation Measures – specific or general form. That is, can we reasonably expect utilities to project heat rate impacts?
- Input on specific measures
- Prior projects that can inform savings and costs

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