CADMUS

R16 – Impact Evaluation: HES and HES-IE

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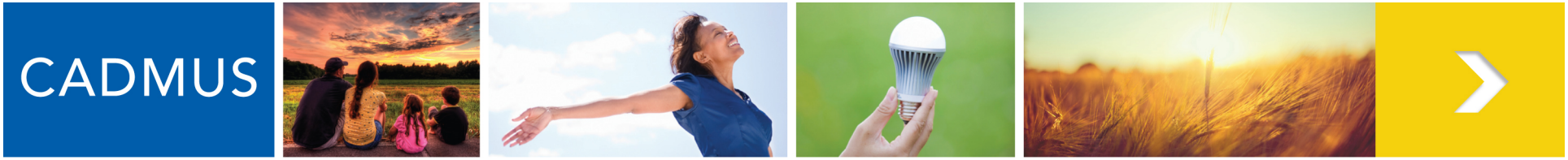
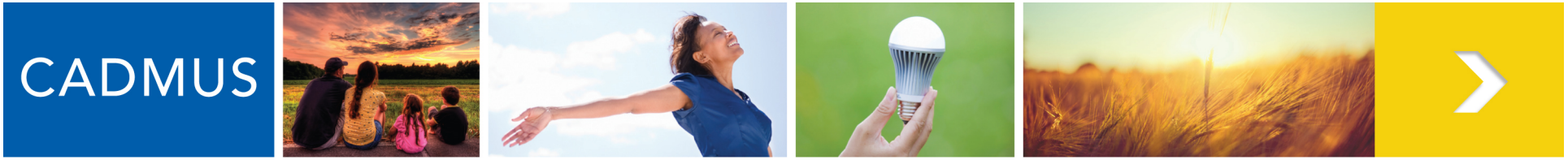


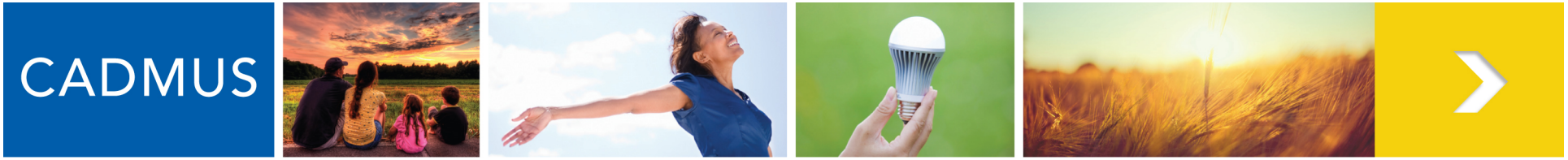
Agenda

- Background
- Methodology
- Key Findings
- Conclusions and Recommendations



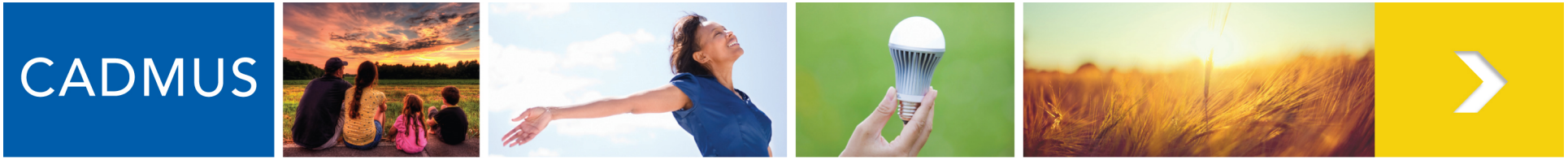
Introduction

- CT EEB required impact evaluation of HES and HES-IE programs
- Study designed to provided evaluated estimates of savings for key program measures
  - To expedite results, program-level impacts were delivered in Vol. 1 report (i.e., Section 1), in advance of measure-level findings (i.e., Section 2).



Study Goals

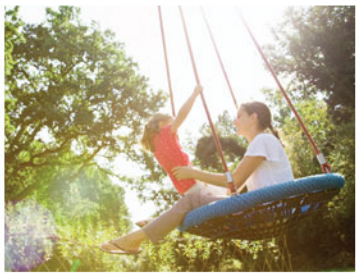
- Perform impact evaluation to assess energy savings for HES and HES-IE – multi-method approach using:
  - (1) billing analysis,
  - (2) simulation modeling, and
  - (3) engineering algorithms
- Provide comparison between reported and evaluated estimates
- Benchmark impacts

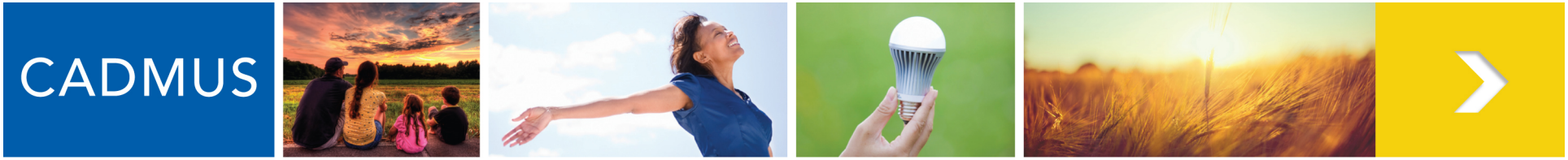


Program Description

- Home Energy Services (HES)
  - Res program offering energy audit + EE measures/weatherization
    - Direct install (core) measures (e.g., CFLs, DHW bundle, air/duct sealing)
    - Additional measures (e.g., appliances, equipment, insulation)
- Home Energy Services – Income Eligible (HES -IE)
  - Same as HES, but primarily no cost to participant
  - HES-IE Subprograms (CL&P-specific)
    - SP2/SP3 – similar to UI (focus on SF and MF)
    - SP1 – leverage WAP/DOE funding
    - SP4 – neighborhood canvassing + direct install
- Study provides impact results for all programs/fuels

Methodology

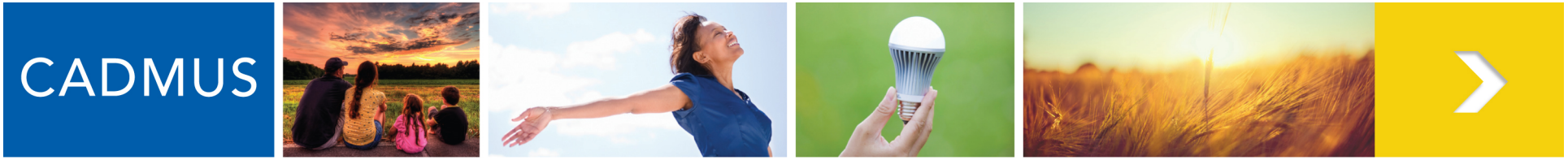




Approach - Overall

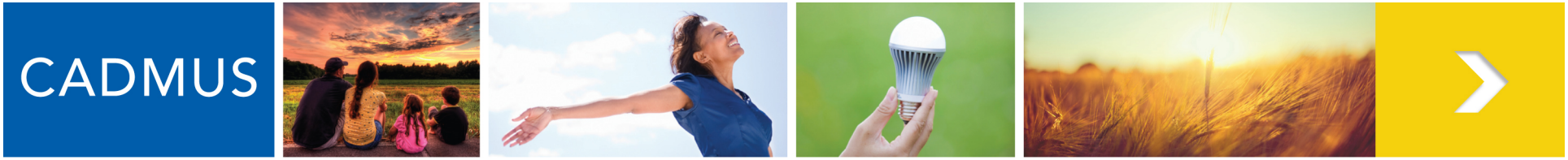
- Section 1 – Whole-House Analysis
  - Billing Analysis
  - Separate analyses of HES-IE SP1/SP4
  - Performed to expedite program-level results

- Section 2 – Measure-Level Analysis
  - Multiple-method approach
    - (1) Billing Analysis – prioritized approach
    - (2) Simulation Modeling – weather-sensitive (e.g., shell)
    - (3) Engineering Algorithms – consistent w/ PSD/secondary sources
  - Omitted HES-IE SP1/SP4
    - SP1 – leverages non-utility funding, resulting in unavailable data
    - SP4 – different program design, mechanism to enroll in SP2/SP3

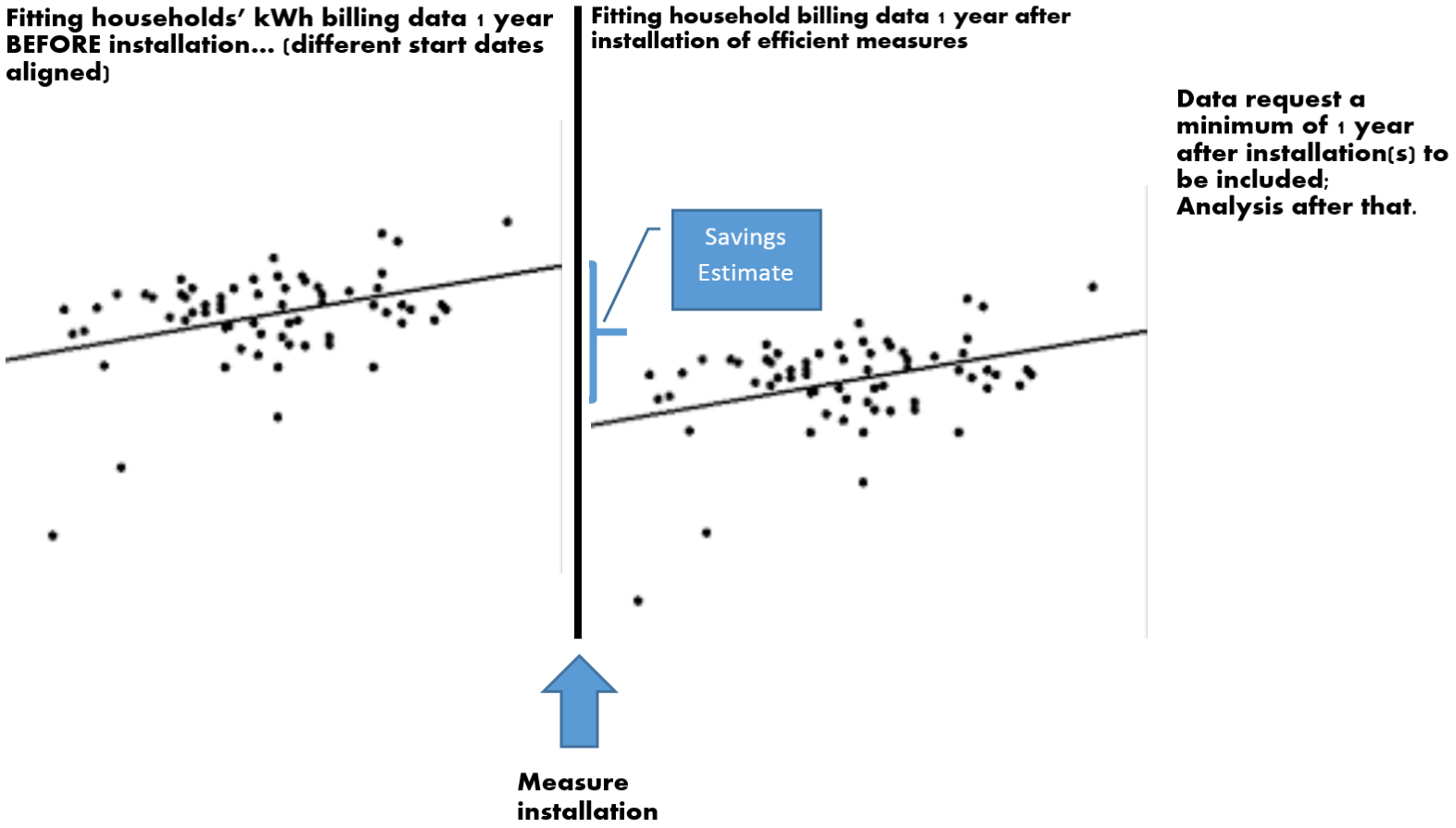


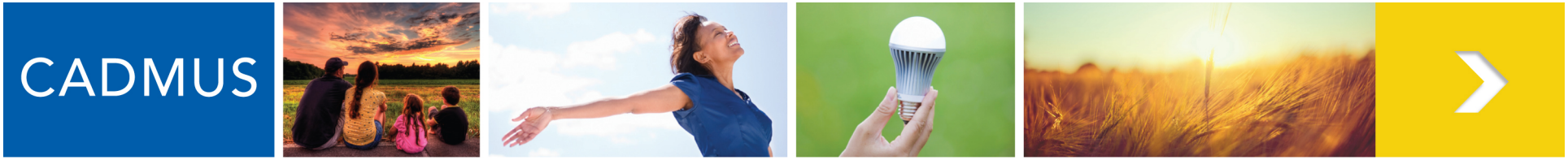
Approach: Section 1 – Whole-House

- Performed billing analysis
  - Industry best practice for eval of whole-house programs
  - Compares approx. 12 months of weather-normalized usage data before and after installation (PY2011)
  - Accounts for a variety of factors influencing energy impacts
    - Measure interaction, energy education, changes in behavior/household, take-back, spillover
  - Estimated impacts for average participant household
    - Fixed-effects statistical regression model



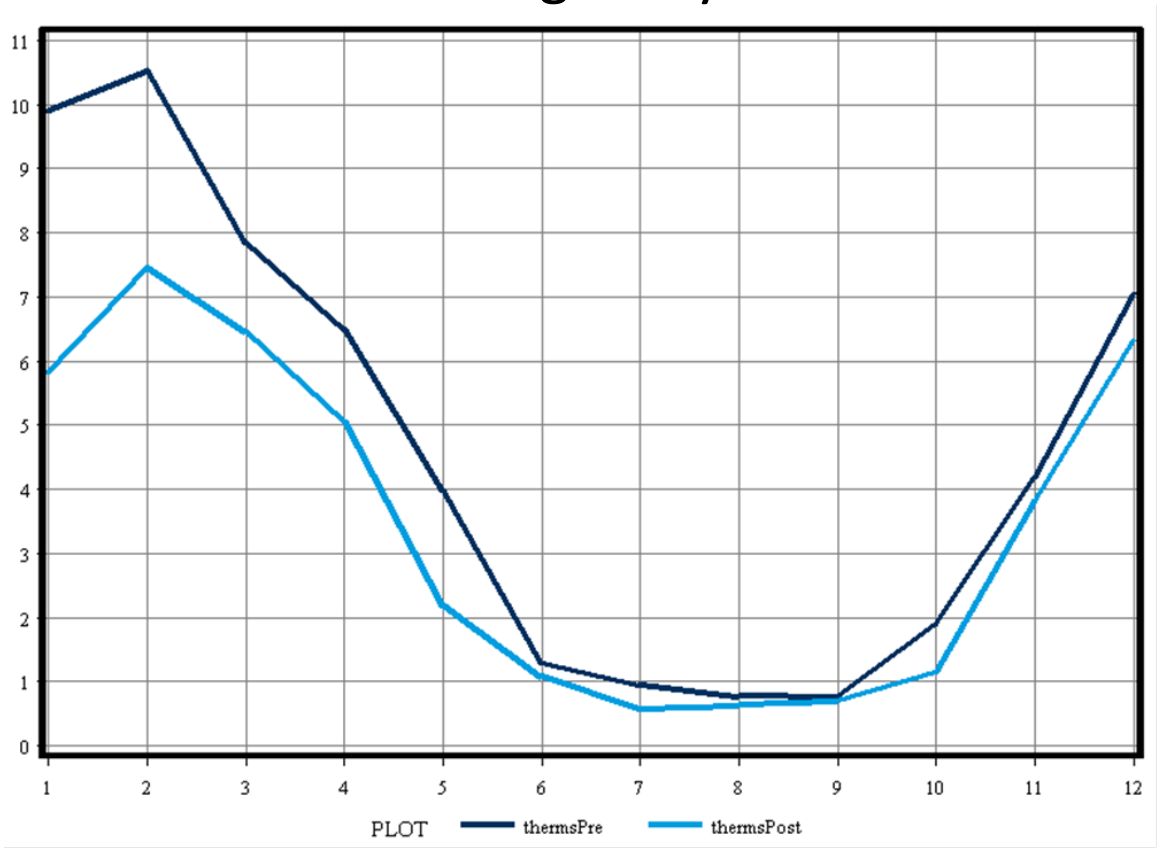
Approach: Section 1 – Whole-House

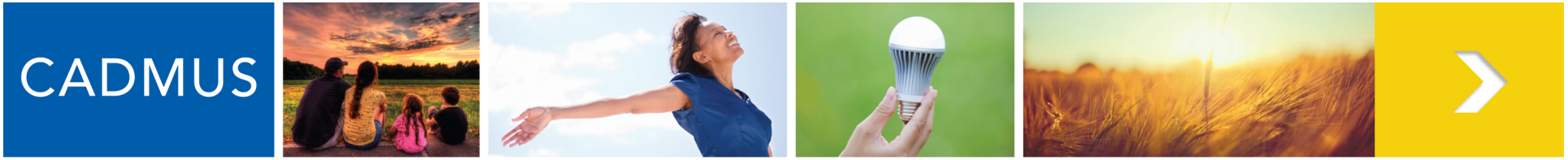




Approach: Section 1 – Whole-House

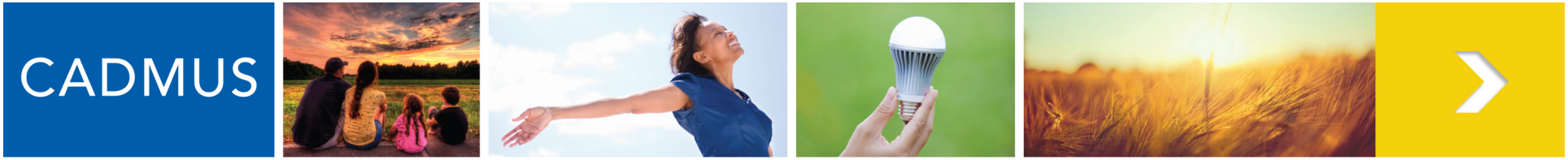
- Example of pre/post installation gas usage profile for individual account from billing analysis





Approach: Section 1 – Whole-House

- Steps for billing analysis approach
  - Participant group
    - PY2011 – driven by available data (needed 12 months post)
    - Begin with census and screen to identify final analysis sample
  - Comparison group
    - "Future" eligible participants selected – best proxy for "nonparticipant"
    - To control for exogenous effects (e.g., macroeconomic)
    - Best practice – using control/comparison group
  - Cleaning data
    - Linking billing data to participant/measure data (from program tracking system)
    - Screening data for various factors
      - E.g., sufficient pre/post billing data, usage anomalies
  - Savings calculation approach
    - Difference of differences

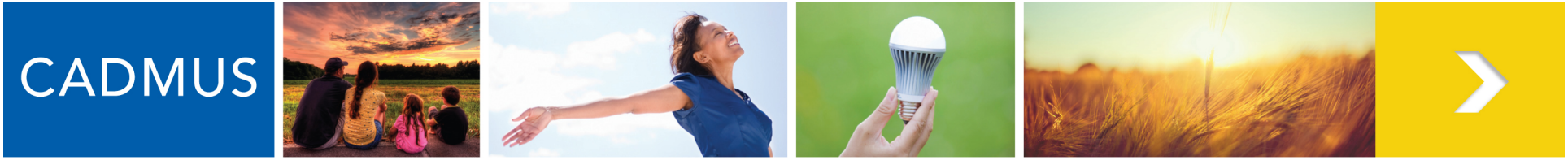


Approach: Section 1 – Whole-House

- Participant and comparison group customers used in billing analysis – derives gross savings for each group

Program	Analysis Group	Electric (n)	Gas (n)
HES	Participant	11,110	1,862
	Comparison	8,547	1,192
HES-IE	Participant	5,481	1,250
	Comparison	5,430	644

- Resulting whole-house estimate precision ranged between ±4-6% for Elec and ±12-14% for Gas at 90% confidence level
- Factors driving model precision:
  - Number of households (Gas: lower)
  - Percent of savings we can observe (Elec: 10-14% vs. Gas: 5-9%)
  - Variation in savings across homes

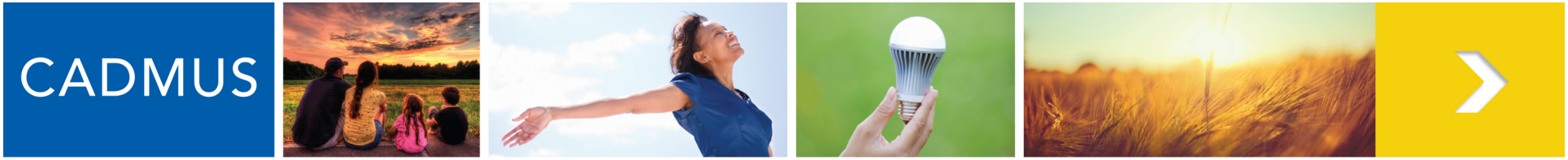


Approach: Section 1 – Whole-House

- Model-specific evaluated savings (per average participant)
  - Adjusted gross or "net" savings subtracts out comparison group / baseline changes
  - "Percent of Pre" approach used to adjust participant impact for the nonparticipant effect

$$Gross\ Savings = (Pre\ Part\ Usage)(Part\ Change\ In\ Usage/Pre\ Part\ Usage - NonPart\ Change/Pre\ NonPart\ Usage)$$

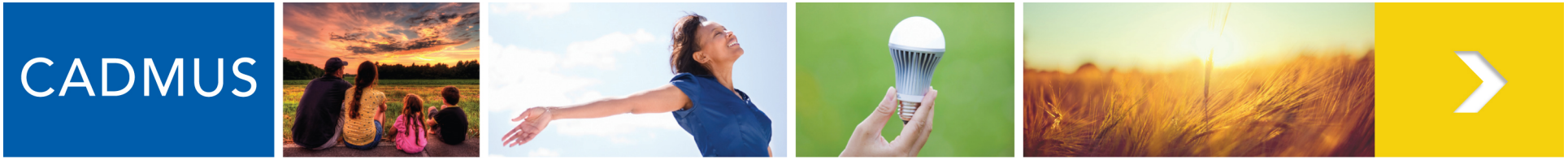
- Realization rate (RR) = evaluated savings / *ex ante* reported savings
- Adjusted gross RRs from analysis applied to 2013-2015 Plan-reported savings to calculate evaluated total program-year savings



Approach: Section 1 – Whole-House

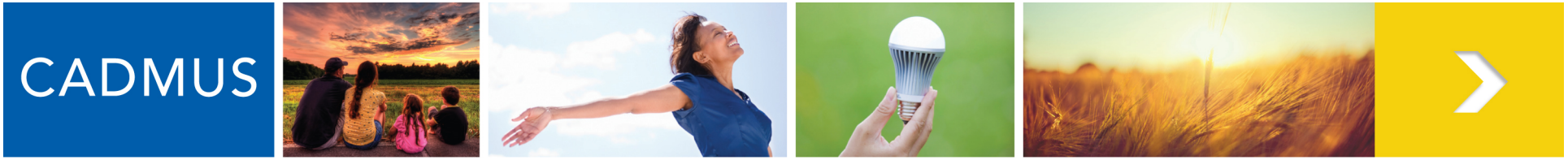
- Approach to estimating Oil/Propane
  - No billing data available for these fuels – not metered
    - Sales difficult to access/unreliable – even so, "lumpy" purchases do not track usage
  - Assume similar usage and homes to natural gas
  - Applied PSD conversion factors to extrapolate impacts for heating and water heating savings from natural gas homes

$$Natural\ Gas\ Fuel\ Savings\ (CCF) \times 102{,}900\ (Btu/CCF)/Fuel\ Conversio$$



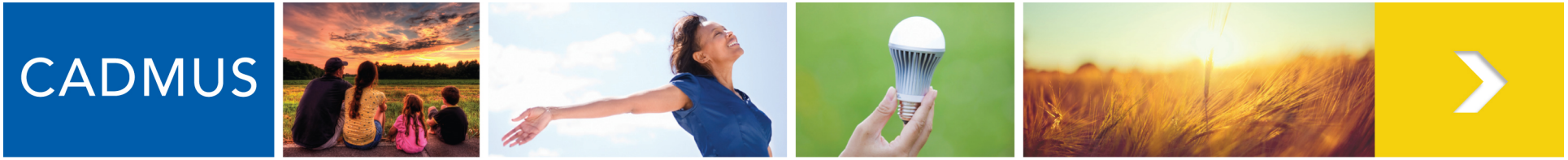
Data Sources

- Program Tracking Data
- Billing Data
- Weather Data
- CT PSD
- CT 2013-2015 Plan
- Indicators of non-utility funded HES-IE projects and “Other” EE program participation (e.g., HER)



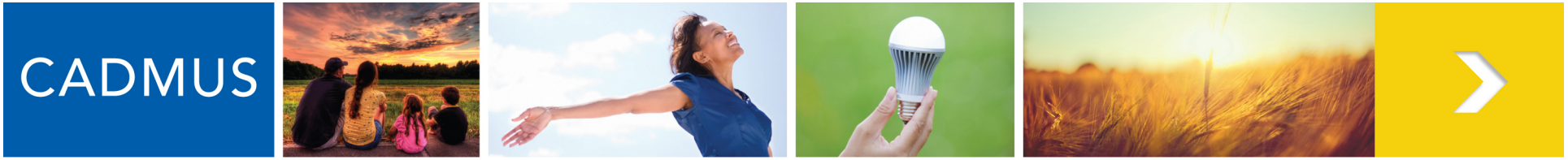
Data Challenges

- Questions around data content / data dictionary
- Delays in receipt of usable data
  - Data files with incorrect unique identifiers
  - Error in mapping fields between billing and participant files
  - Multifamily participant match to billing data



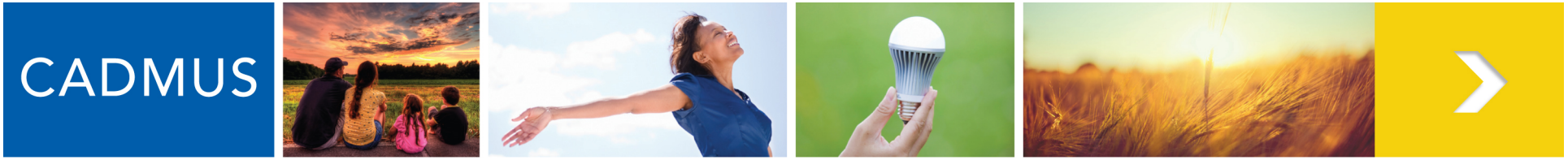
Approach: Section 2 – Measure-Level

- Savings calculation approach – hierarchical:
  - (1) Billing analysis
    - Highest priority approach
    - Not used in cases with low measure frequency or lack of discernable effect (where relative precision is ±35% or more)
  - (2a) Calibration simulation modeling
    - For measures with interaction effects
    - Using DOE-2-based models calibrated to pre-period usage
  - (2b) Engineering algorithms
    - For measures without interactive effects
    - Based on adopted calculations/assumptions primarily from CT PSD
      - Combination of historical CT info and regional/national sources



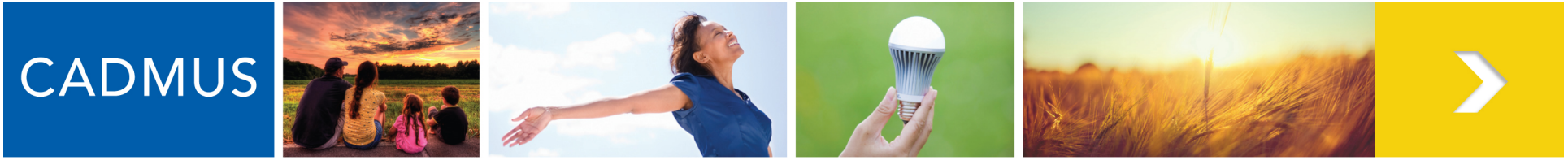
Approach: Section 2 – Measure-Level

- Billing Analysis
  - Same approach as Section 1, now looking at measure-specific effects (not whole-house)
    - Models use sets of measure-specific dummy variables
    - Separate models by program/fuel type
    - Same analysis samples of participants/nonparticipants
  - Lighting interactive effects – separate study (R67) provided factors to consider impacts independent of interaction, cited in report



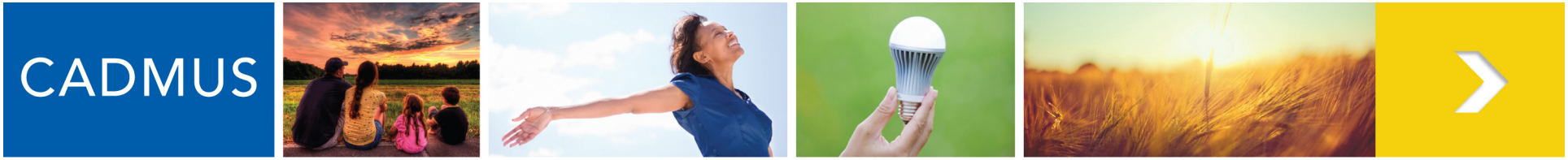
Approach: Section 2 – Measure-Level

- Simulation Modeling detail
  - DOE-2 based models
    - Calibrated to pre-period energy consumption
    - Models developed for each program, building-type, heating fuel combination (multiple prototypes)
  - First developed calibrated baseline, then changed settings to mimic new measures installed (e.g., changing R-value or leakage)
  - Compared baseline to efficient scenario to measure savings impact



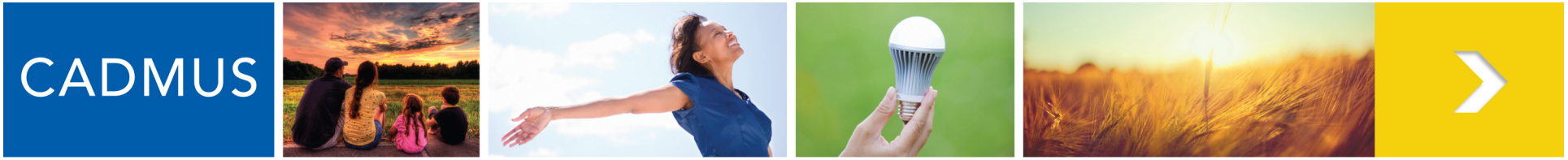
Approach: Section 2 – Measure-Level

- Engineering Analysis
  - Primarily relied on 2013 CT PSD for algorithms
    - Some supplemental sources (e.g., TRMs)
  - Different savings approach outlined in PSD
    - HES received "replace on burnout" savings
    - HES-IE received "early replacement" savings



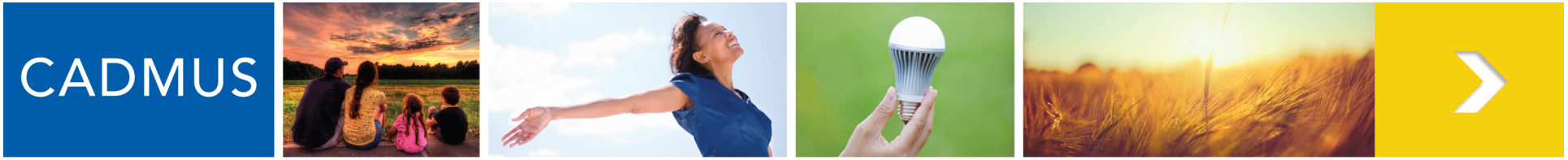
Approach: Section 2 – Measure-Level

Category	Measure	HES		
		Electric	Gas	Oil/Propane
Appliance	Clothes Washer	Engineering Algorithm	Engineering Algorithm	–
	Dehumidifier	Engineering Algorithm	–	–
	Freezer	Engineering Algorithm	–	–
	Refrigerator	Engineering Algorithm	–	–
	Appliance Other*	Reported *Ex Ante*	–	–
HVAC	Central AC	Engineering Algorithm	–	–
	Duct Sealing	Simulation Modeling	Simulation Modeling	Simulation Modeling
	Ductless Heat Pump	Billing Analysis (±35%)	–	–
	Ground-Source Heat Pump	Engineering Algorithm	–	–
	Heat Pump	Engineering Algorithm	–	–
	Heating System Replacement	Engineering Algorithm	Engineering Algorithm	–
Lighting	Lighting	Billing Analysis (±6%)	–	–
Other	Other	Reported *Ex Ante*	–	–
Shell	Air Sealing	Billing Analysis (±21%)	Billing Analysis (±14%)	Billing Analysis (±14%)
	Attic Insulation	Simulation Modeling	Simulation Modeling	Simulation Modeling
	Wall Insulation	Simulation Modeling	Simulation Modeling	Simulation Modeling
	Insulation Other**	Reported *Ex Ante*	Reported *Ex Ante*	Reported *Ex Ante*
	Windows	Engineering Algorithm	Engineering Algorithm	–
Water Heat	Domestic Hot-Water (DHW) Bundle***	Billing Analysis (±21%)	Engineering Algorithm	Engineering Algorithm
	Water Heater Replacement	–	Reported *Ex Ante*	–
	Heat Pump Water Heater	Reported *Ex Ante*	–	–



Approach: Section 2 – Measure-Level

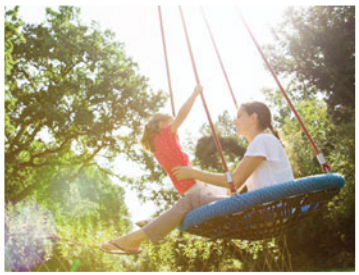
Category	Measure	HES-IE		
		Electric	Gas	Oil/Propane
Appliance	Freezer	Billing Analysis (±32%)	–	–
	Refrigerator	Billing Analysis (±28%)	–	–
	Appliance Other*	Billing Analysis (±24%)	Reported *Ex Ante*	–
HVAC	Central AC	Engineering Algorithm	–	–
	Duct Sealing	Simulation Modeling	Simulation Modeling	Simulation Modeling
	Ductless Heat Pump	Billing Analysis (±32%)	–	–
	Heating System Replacement	–	Billing Analysis (±14%)	Billing Analysis (±14%)
	Window AC	Engineering Algorithm	–	–
Lighting	Lighting	Billing Analysis (±6%)	–	–
Other	Other	Reported *Ex Ante*	Reported *Ex Ante*	–
Shell	Air Sealing	Simulation Modeling	Billing Analysis (±31%)	Billing Analysis (±31%)
	Attic Insulation	Simulation Modeling	Simulation Modeling	Simulation Modeling
	Wall Insulation	Simulation Modeling	Billing Analysis (±30%)	Billing Analysis (±30%)
	Insulation Other**	Reported *Ex Ante*	–	–
	Windows	Engineering Algorithm	Engineering Algorithm	Engineering Algorithm
Water Heat	DHW Bundle***	Engineering Algorithm	Billing Analysis (±26%)	Billing Analysis (±26%)
	Water Heater Temp Setback	Engineering Algorithm	Engineering Algorithm	Engineering Algorithm
	Water Heater Replacement	Reported *Ex Ante*	Reported *Ex Ante*	–

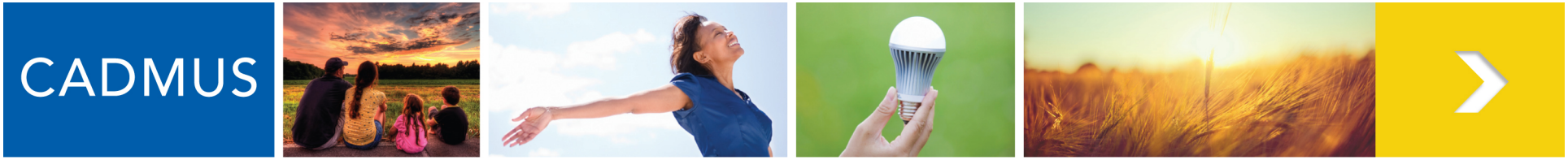


Approach: Section 2 – Measure-Level

- Notes on billing analysis and precision:
  - Estimates statistically significant at 99% confidence level
    - Not due to random variation
  - "Precision" represents the variation in the effect a measure has on consumption
    - Different than precision associated with sampling uncertainty (e.g., "90/10")
  - Engineering analysis also has uncertainty, though unknown/unobserved, rarely reported
  - Best practice use of actual participant population data, rather than engineering assumptions
    - Results in robust estimates of savings, where higher precision does not necessarily indicate a poor estimate

Key Findings - Overall

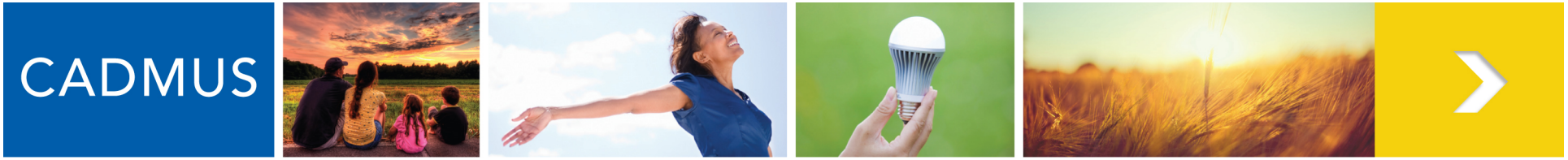




Overall Findings

Program	Electric Savings		Gas Savings	
	Section 1	Section 2	Section 1	Section 2
HES	117%	111%	58%	64%
HES-IE	76%	79%	51%	55%

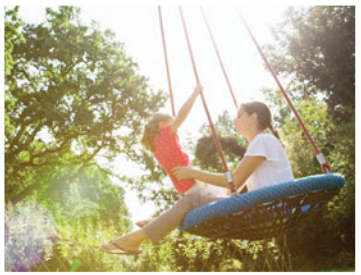
- Two approaches with different insights:
  - Section 1 – Whole-house impacts
    - Best assessment of overall program-level energy savings
    - Account for broad range of factors
    - Robust estimates (precision ranging between ±4-14%)
  - Section 2 – Measure-level impacts
    - Used to inform PSD and program design

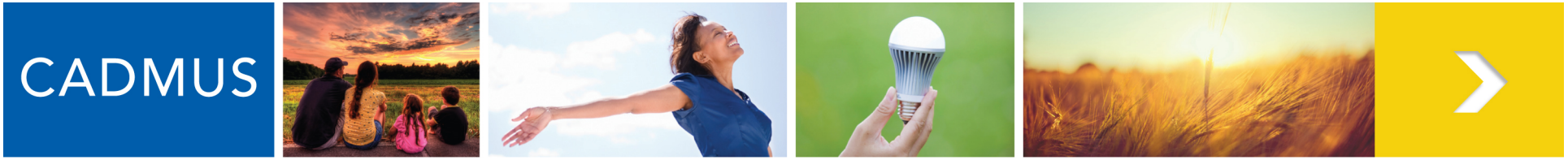


Overall Findings

- Factors driving realization rates
  - Differences in energy use between HES and HES-IE
    - HES (11,279 kWh) vs. HES-IE (7,292 kWh)
  - Differences in *ex ante* savings (denominator of RR)
    - RRs may be different between programs, given differences in *ex ante* savings
    - Example: DHW measures 82% for HES and 28% for HES-IE
      - Evaluated savings of 395 kWh and 390 kWh
      - *Ex ante* savings of 482 kWh and 1,372 kWh
  - Differences in measure distribution between HES/HES-IE and elec/gas programs
    - Example: 14% of HES participants in analysis had DHW measures, compared to 32% of HES-IE

Section 1 – Whole-House Findings

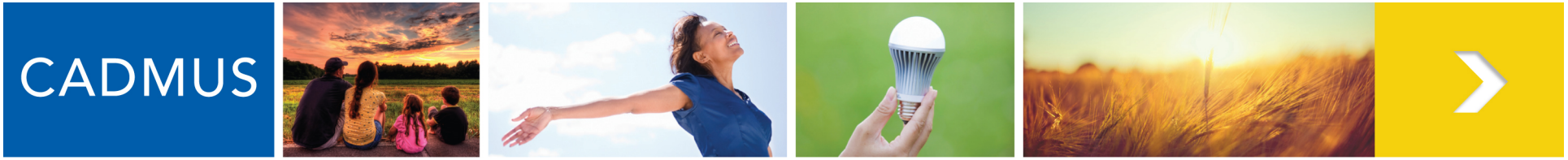




Section 1 – Findings: HES Elec

Group	Utility	Model Savings (kWh)	Reported *Ex Ante* Savings (kWh)	Realization Rate	Model Savings as Percentage of Pre-Usage	Reported *Ex Ante* Savings as Percentage of Pre-Usage
Adjusted gross savings	CL&P	1,082	936	116%	9%	8%
	UI	1,053	837	126%	12%	9%
	Overall	**1,067**	**914**	**117%**	**9%**	**8%**

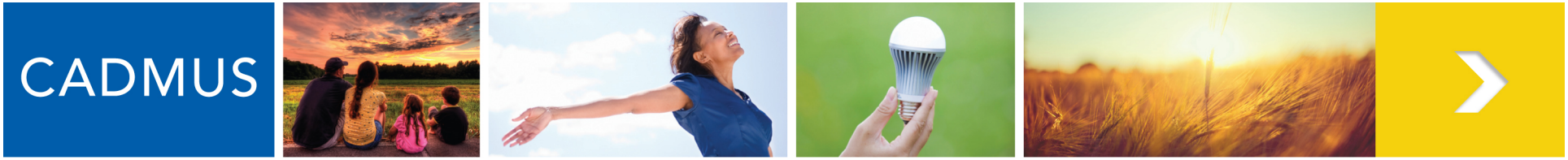
- RRs > 100%
- High frequency of core measures: lighting (97%), air sealing (67-76%), duct sealing (15-30%), DHW bundle (9-16%)
- Lower levels of "add-on" measures
  - Higher frequency of heat pumps, dehumidifiers, and clothes washers for CL&P



Section 1 – Findings: HES Gas

Group	Utility	Model Savings (CCF)	Reported *Ex Ante* Savings (CCF)	Realization Rate	Model Savings as Percentage of Pre-Usage	Reported *Ex Ante* Savings as Percentage of Pre-Usage
Adjusted gross savings	CNG	59	88	67%	5%	8%
	SCG	46	103	45%	4%	10%
	YGS	55	85	65%	6%	9%
	Overall	**55**	**91**	**60%**	**5%**	**9%**

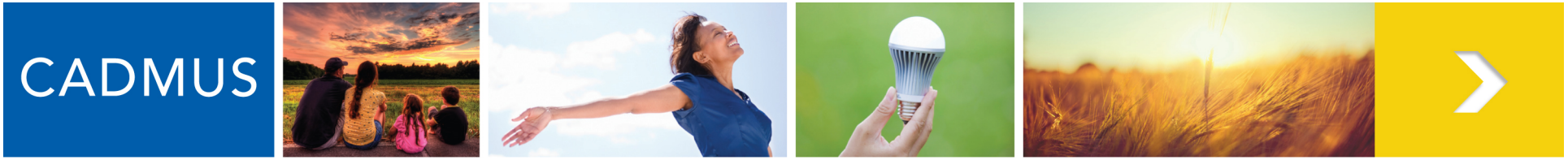
- RRs are approx. 60%
  - Section 2 shows *ex ante* assumptions for some measures underlie this result
- High frequency of core measures: air sealing (90-97%), DHW bundle (63-75%), and duct sealing (12-26%)
- Lower levels of "add-on" measures
- Nonparticipant usage decrease, ranging from 15-19 CCF



Section 1 – Findings: HES Oil/Propane

Fuel Type	Configuration	n	Gas Model Savings (CCF per participant)	Conversion Factor (gallons/CCF)	Converted Oil/ Propane Savings (gallons per participant)	Total Oil/Propane Savings (gallons)
Oil	Heating Only	3,693	41	0.7419	30	112,506
	Water Heating Only	187	14	0.7419	10	1,899
	Combo	8,196	55	0.7419	41	332,918
	Overall	**12,076**	**n/a**	**n/a**	**n/a**	**447,323**
Propane	Heating Only	238	41	1.1267	46	11,011
	Water Heating Only	166	14	1.1267	15	2,560
	Combo	365	55	1.1267	62	22,516
	Overall	**769**	**n/a**	**n/a**	**n/a**	**36,087**

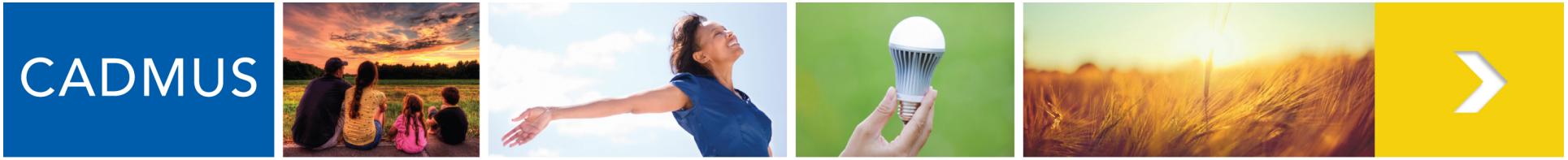
- Estimates of savings in CCF and gallons; no *ex ante* for comparison



Section 1 – Findings: HES-IE Elec (SP2/SP3)

Group	Utility	Model Savings (kWh)	Reported *Ex Ante* Savings (kWh)	Realization Rate	Model Savings as Percentage of Pre-Usage	Reported *Ex Ante* Savings as Percentage of Pre-Usage
Adjusted gross savings	CL&P	1,011	1,481	68%	14%	20%
	UI	1,011	966	105%	14%	14%
	Overall	**1,005**	**1,281**	**78%**	**14%**	**18%**

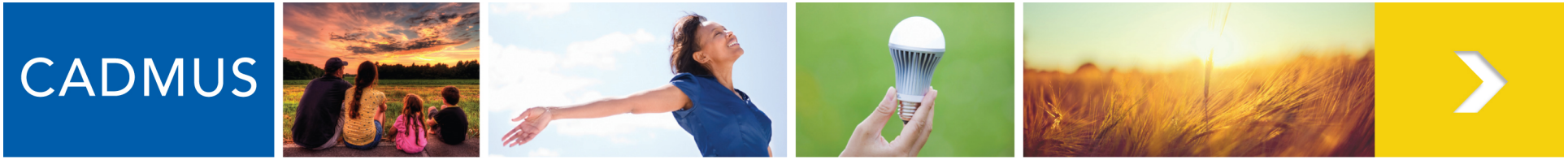
- Variation in RRs (68% vs. 105%) – driven largely by ductless heat pumps (DHP)
  - Higher freq of DHP occurred in MF (24%) vs. SF (<1%)
  - *Ex ante* DHP savings represent highest portion of expected MF HES-IE electric savings
  - *Ex ante* DHP estimates reflect high savings compared to pre-usage (15% for SF and 29% for MF)
  - RR by building type may reflect this distinction (SF = 105% , MF = 64%)
- Higher frequency of core measures: lighting (84-96%), air sealing (32-53%) DHW bundle (21-39%)
  - Add-on: Ductless heat pumps (7-19%) and appliances (13-29%)
- Nonparticipant usage increase, ranging from 80-100 kWh



Section 1 – Findings: HES-IE Gas (SP2/SP3)

Group	Utility	Model Savings (CCF)	Reported *Ex Ante* Savings (CCF)	Realization Rate	Model Savings as Percentage of Pre-Usage	Reported *Ex Ante* Savings as Percentage of Pre-Usage
Adjusted gross savings	CNG	67	152	44%	7%	16%
	SCG	71	124	57%	8%	14%
	YGS	75	161	47%	11%	23%
	Overall	**73**	**149**	**49%**	**9%**	**18%**

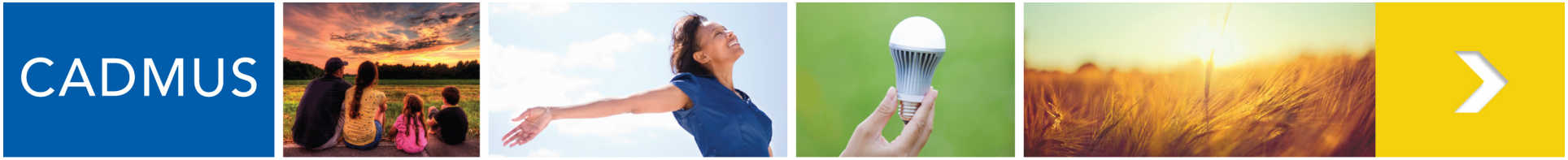
- RRs are approx. 50%
  - Section 2 shows *ex ante* assumptions for some measures underlie this result
- Higher frequency of core measures: air sealing (68-96%), DHW bundle (61-80%)
  - Add-on: attic insulation (4-26%) and wall insulation (3-22%)
    - Highest percentages in YGS, which aligns with overall savings and percentage savings results
- Nonparticipant usage decrease ranging from 18-23 CCF for CNG/YGS, increase for SCG by 3 CCF



Section 1 – Findings: HES-IE Oil/Propane

Fuel Type	Configuration	n*	Gas Model Savings (CCF per participant)	Conversion Factor (gallons/CCF)	Converted Oil/ Propane Savings (gallons per participant)	Total Oil/Propane Savings (gallons)
Oil	Heating Only	1,531	55	0.7419	40	61,962
	Water Heating Only	117	18	0.7419	13	1,578
	Combo	2,859	73	0.7419	54	154,279
	Overall	**4,507**	**n/a**	**n/a**	**n/a**	**217,820**
Propane	Heating Only	63	55	1.1267	61	3,872
	Water Heating Only	66	18	1.1267	20	1,352
	Combo	66	73	1.1267	82	5,409
	Overall	**195**	**n/a**	**n/a**	**n/a**	**10,633**

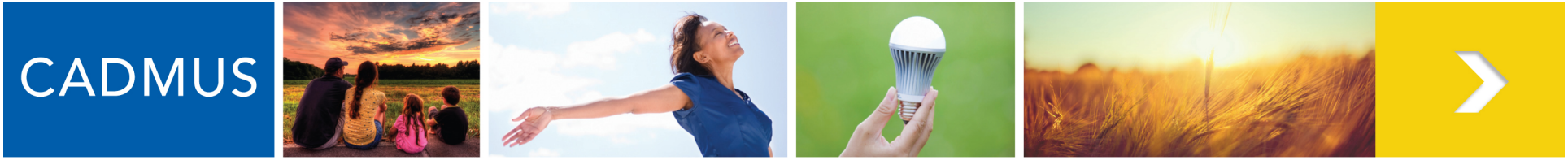
- Estimates of savings in CCF and gallons; no *ex ante* for comparison



Section 1 – Findings: HES-IE Elec (SP1/SP4)

HES-IE Subgroup	Model Savings (kWh)	Reported *Ex Ante* Savings (kWh)	Realization Rate	Model Savings as Percentage of Pre-Usage	Reported *Ex Ante* Savings as Percentage of Pre-Usage
SP1	1,074	1,278	84%	12%	15%
SP4	629	1,037	61%	10%	16%

- Higher frequency of core measures: lighting (93-96%), DHW bundle (26-77%)
  - SP1 showed higher refrigerator replacement (23%)
- Nonparticipant usage increase ranging from 160 kWh (SP4) to 314 kWh (SP1), consistent trend seen in SP2/SP3
- SP1 similar kWh and percentage savings to HES-IE SP2/SP3 electric (1,005 kWh, 14%)
  - SP4 not as comparable due to program design
- RRs may be driven by assumed savings (*ex ante*) or installation frequencies

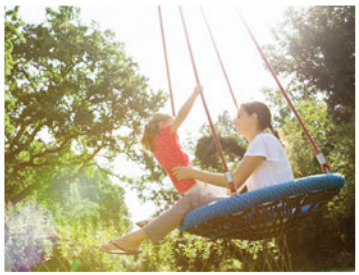


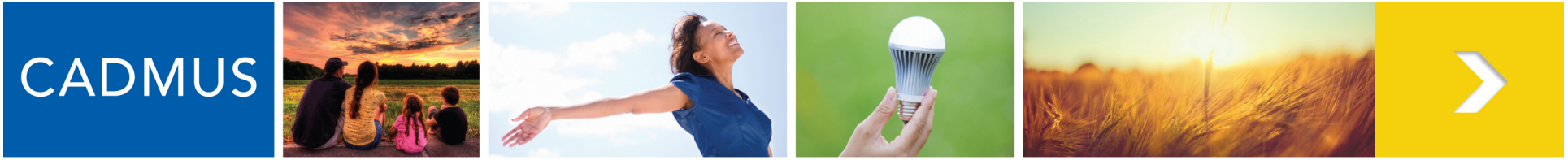
Section 1 – Findings: HES-IE Gas (SP1/SP4)

HES-IE Subprogram	Model Savings (CCF)	Reported *Ex Ante* Savings (CCF)	Realization Rate	Model Savings as Percent of Pre-Usage	Reported *Ex Ante* Savings as Percent of Pre-Usage
SP1	82	110	75%	8%	11%
SP4	32	60	53%	4%	8%

- Higher frequency of core measures: air sealing (42-63%), DHW bundle (77-96%)
  - SP1 attic insulation (11%)
- Nonparticipant decrease usage (13 CCF), consistent trend seen in SP2/SP3 (CNG/YGS)
- SP1 similar CCF and percentage savings to HES-IE SP2/SP3 gas (72 CCF, 9%)
  - SP4 not as comparable due to program design
- RRs may be driven by assumed savings (*ex ante*) or installation frequencies

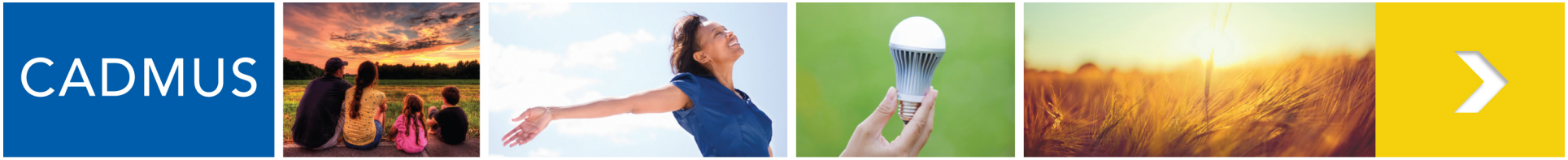
Section 2 – Measure-Level Findings





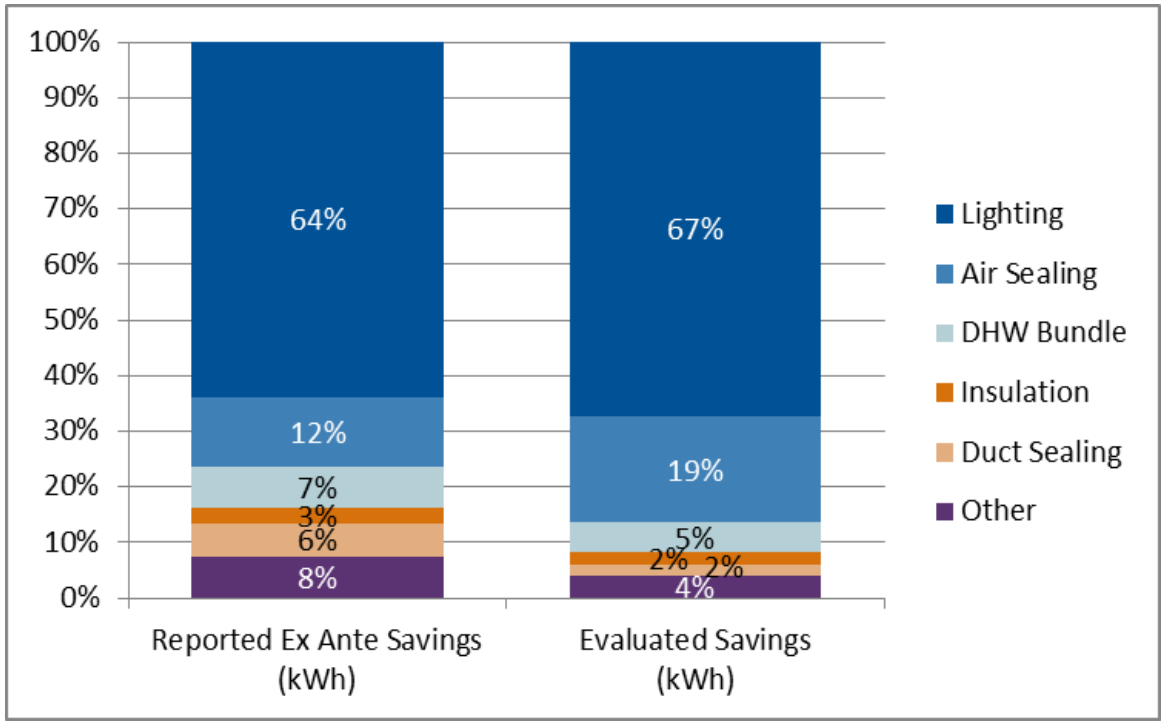
Section 2 – Findings: HES Elec

Category	Measure	Reported *Ex Ante* Savings (kWh/ Household) * (A)	Gross Savings (kWh/ Household) (B)	Realization Rate (B/A)	Method
Appliance	Dehumidifier	382	31	8%	Engineering Algorithm
Appliance	Freezer	705	66	9%	Engineering Algorithm
Appliance	Refrigerator	243	39	16%	Engineering Algorithm
Appliance	Clothes Washer	1,430	644	45%	Engineering Algorithm
HVAC	Central AC	471	386	82%	Engineering Algorithm
HVAC	Duct Sealing	309	103	33%	Simulation Modeling
HVAC	Heating System Replacement	285	380	133%	Engineering Algorithm
HVAC	Heat Pump	977	758	78%	Engineering Algorithm
HVAC	Ductless Heat Pump**	2,844	1,311	46%	Billing Analysis (±35%)
HVAC	Ground-Source Heat Pump	2,018	1,982	98%	Engineering Algorithm
Lighting	Lighting	652	782	120%	Billing Analysis (±6%)
Other	Other	259	259	100%	Reported *Ex Ante*
Shell	Air Sealing	154	269	175%	Billing Analysis (±21%)
Shell	Insulation Other	368	368	100%	Reported *Ex Ante*
Shell	Windows	3,190	3,196	100%	Engineering Algorithm
Shell	Attic Insulation	708	481	68%	Simulation Modeling
Shell	Wall Insulation	1,876	1,575	84%	Simulation Modeling
Water Heat	Heat Pump Water Heater	1,762	1,762	100%	Reported *Ex Ante*
Water Heat	DWH Bundle	482	359	82%	Billing Analysis (±21%)

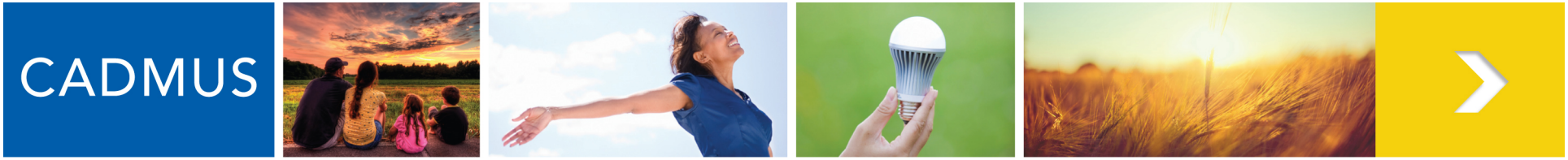


Section 2 – Findings: HES Elec

- Distribution of Electric Savings by Measure

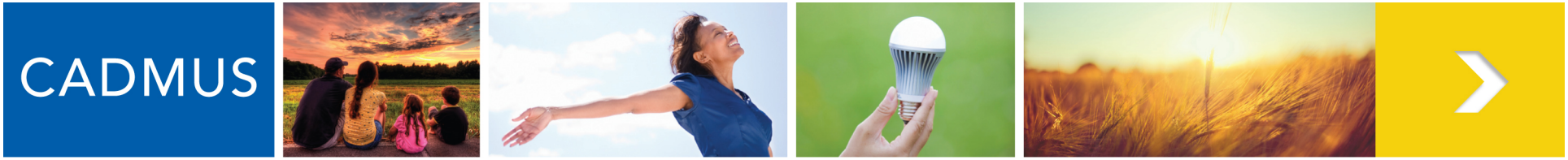


- Higher evaluated savings for lighting and air sealing
  - Represent highest portion of program savings (86%)
- Air sealing results in largest difference (7%)
- Program-Level RR: 111%



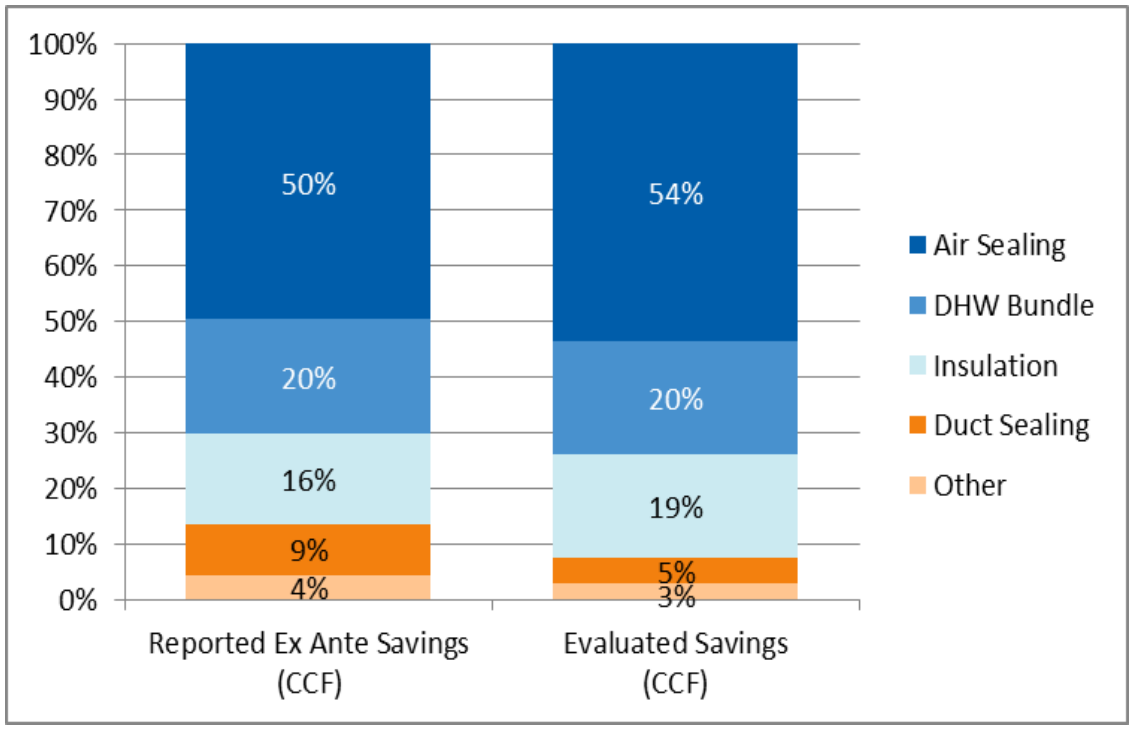
Section 2 – Findings: HES Gas

Category	Measure	Reported *Ex Ante* Savings (CCF/ Household) * (A)	Gross Savings (CCF/ Household) (B)	Realization Rate (B/A)	Method
Appliance	Clothes Washer	20	2	8%	Engineering Algorithm
HVAC	Duct Sealing	45	19	42%	Simulation Modeling
HVAC	Heating System Replacement	1,004	229	23%	Engineering Algorithm
Shell	Air Sealing	62	57	91%	Billing Analysis (±14%)
Shell	Insulation Other	175	175	100%	Reported *Ex Ante*
Shell	Windows	136	147	108%	Engineering Algorithm
Shell	Attic Insulation	179	135	76%	Simulation Modeling
Shell	Wall Insulation	449	224	50%	Simulation Modeling
Water Heat	Water Heater Replacement	56	56	100%	Reported *Ex Ante*
Water Heat	DWH Bundle	17	14	84%	Engineering Algorithm

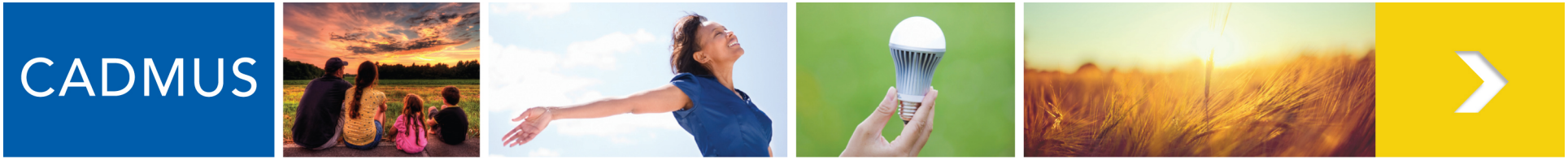


Section 2 – Findings: HES Gas

- Distribution of Gas Savings by Measure



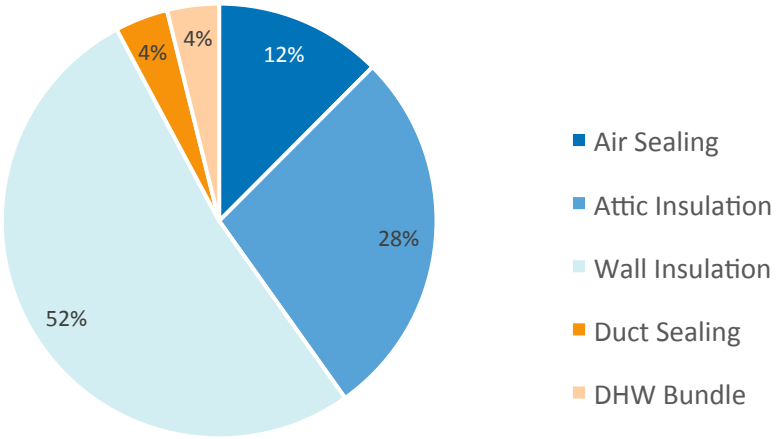
- RRs about 90% for top measures (air sealing, DHW), lower for insulation
  - Represent highest portion of program savings (>90%)
- Program-level RR: 64%

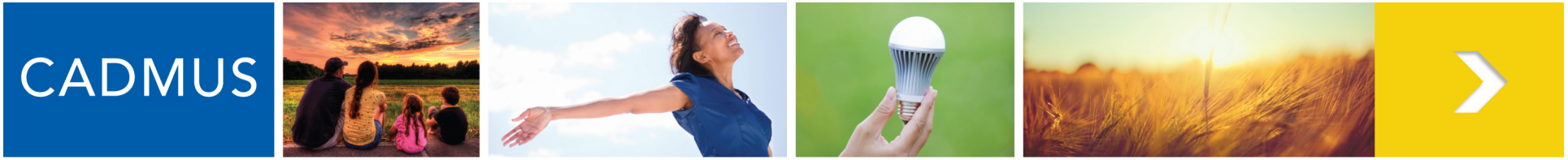


Section 2 – Findings: HES Oil/Propane

Category	Measures	Average Evaluated Gross Savings (CCF)*	Oil		Propane	
			Conversion Factor (gallons/CCF)	Oil Savings per Participant (Gallons)**	Conversion Factor (gallons/ CCF)	Propane Savings per Participant (Gallons)
Shell and Duct*	Air Sealing	57	0.7419	41	1.1267	64
	Attic Insulation	126		91		142
	Wall Insulation	237		171		267
	Duct Sealing	18		13		21
DHW	Showerhead	9.4		6.9		10.5
	Faucet Aerators	3.8		2.9		4.3
	Pipe Insulation	3.9		2.9		4.4

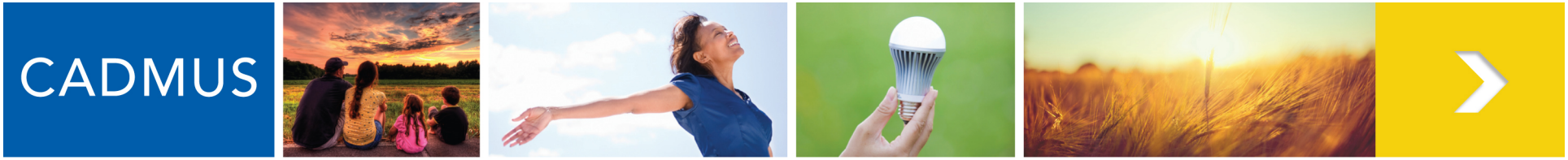
- Detail of measures with highest average savings impact





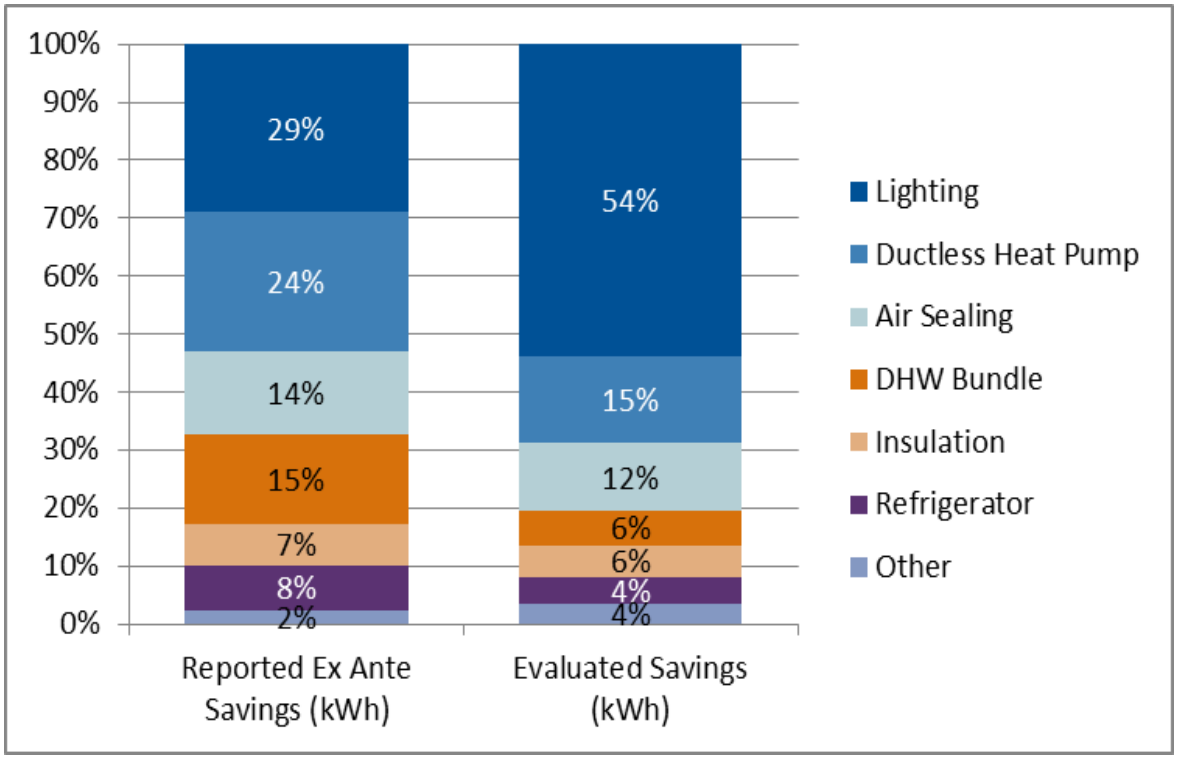
Section 2 – Findings: HES-IE Elec

Category	Measure	Reported *Ex Ante* Savings (kWh/ Household)* (A)	Gross Savings (kWh/ Household) (B)	Realization Rate (B/A)	Method
Appliance	Freezer	733	728	99%	Billing Analysis (±32%)
Appliance	Refrigerator	758	318	42%	Billing Analysis (±28%)
Appliance	Appliance Other	353	498	141%	Billing Analysis (±24%)
HVAC	Central AC	98	98	100%	Engineering Algorithm
HVAC	Duct Sealing	262	81	31%	Simulation Modeling
HVAC	Ductless Heat Pump	1,731	803	46%	Billing Analysis (±32%)
HVAC	Window AC	94	46	49%	Engineering Algorithm
Lighting	Lighting	467	647	138%	Billing Analysis (±6%)
Other	Other	637	637	100%	Reported *Ex Ante*
Shell	Air Sealing	342	208	61%	Simulation Modeling
Shell	Insulation Other	153	153	100%	Reported *Ex Ante*
Shell	Windows	1,295	2,253	174%	Engineering Algorithm
Shell	Attic Insulation	2,306	1,429	62%	Simulation Modeling
Shell	Wall Insulation	2,326	716	31%	Simulation Modeling
Water Heat	DWH Bundle	1,372	390	28%	Engineering Algorithm
Water Heat	Temp Setback	87	78	90%	Engineering Algorithm

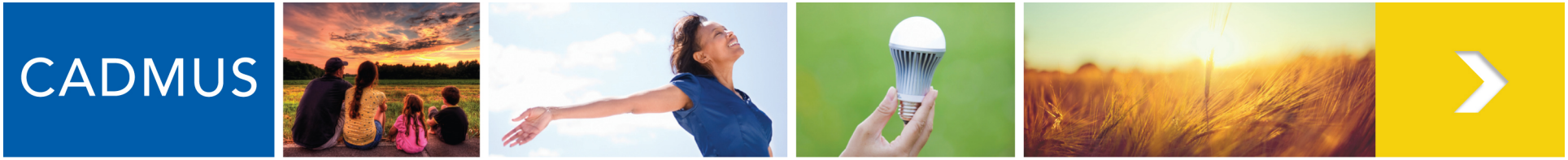


Section 2 – Findings: HES-IE Elec

- Distribution of Electric Savings by Measure

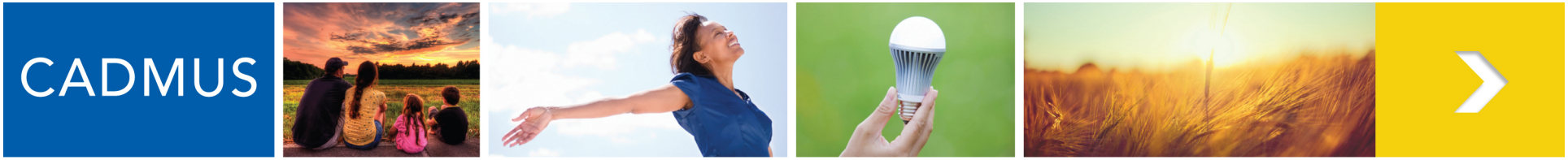


- Higher evaluated savings for lighting, while lower for DHP, air sealing, and DHW bundle
  - Represent highest portion of program savings (85%)
- DHP and DHW result in largest difference (9% each)
- Program-level RR: 79%



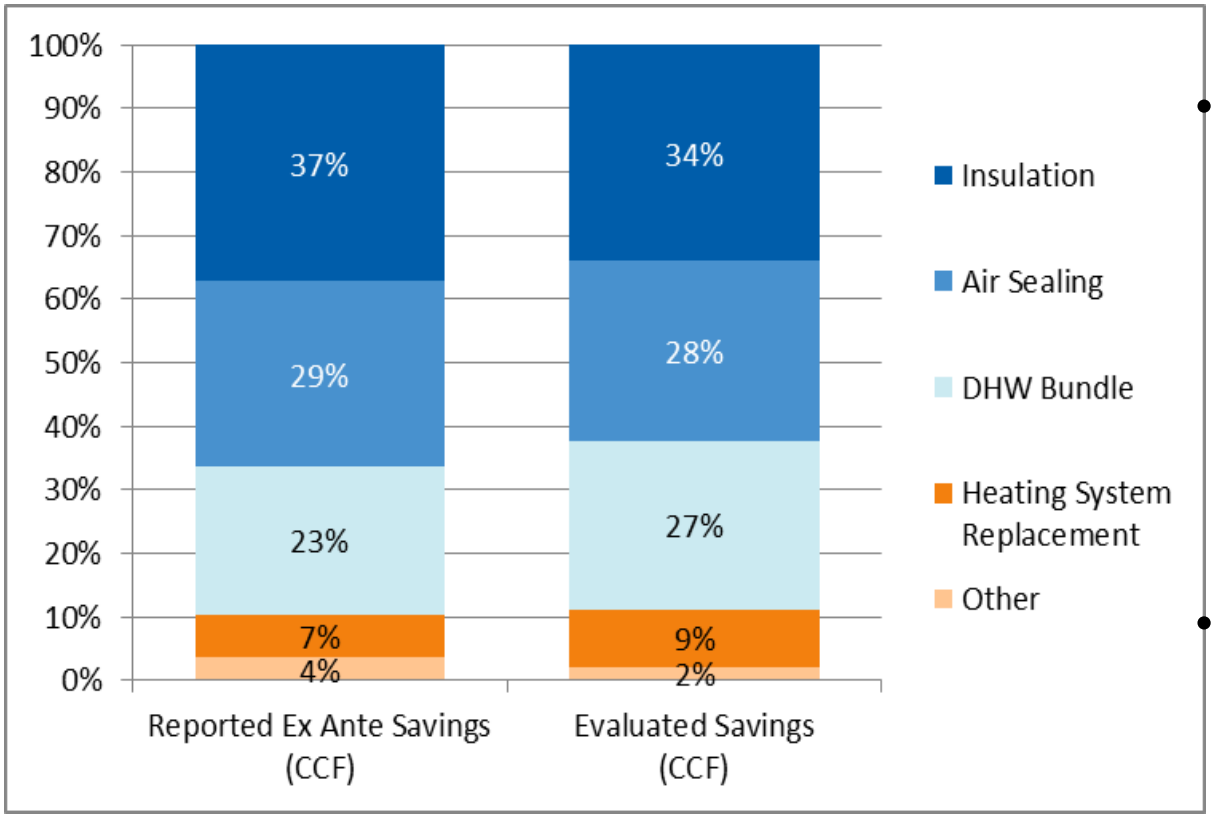
Section 2 – Findings: HES-IE Gas

Category	Measure	Reported Ex Ante Savings (CCF/ Household)* (A)	Gross Savings (CCF/ Household) (B)	Realization Rate (B/A)	Method
Appliance	Appliance Other	8	8	100%	Reported *Ex Ante*
HVAC	Duct Sealing	174	28	16%	Simulation Modeling
HVAC	Heating System Replacement	128	107	84%	Billing Analysis (±14%)
Other	Other	23	23	100%	Reported *Ex Ante*
Shell	Air Sealing	59	36	61%	Billing Analysis (±31%)
Shell	Windows	25	23	93%	Engineering Algorithm
Shell	Attic Insulation	152	197	129%	Simulation Modeling
Shell	Wall Insulation	304	96	32%	Billing Analysis (±30%)
Water Heat	Temp Setback	6	4	62%	Engineering Algorithm
Water Heat	DWH Bundle	41	29	72%	Billing Analysis (±26%)

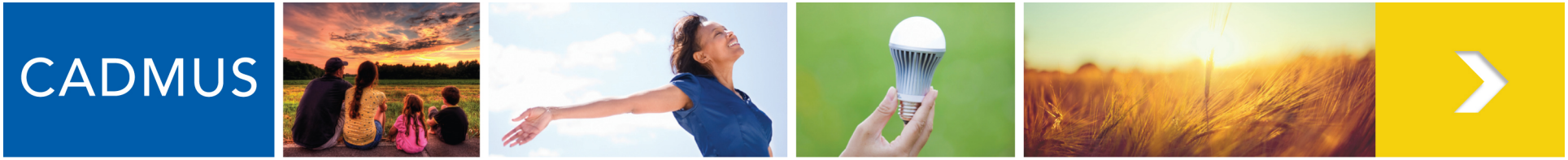


Section 2 – Findings: HES-IE Gas

- Distribution of Gas Savings by Measure

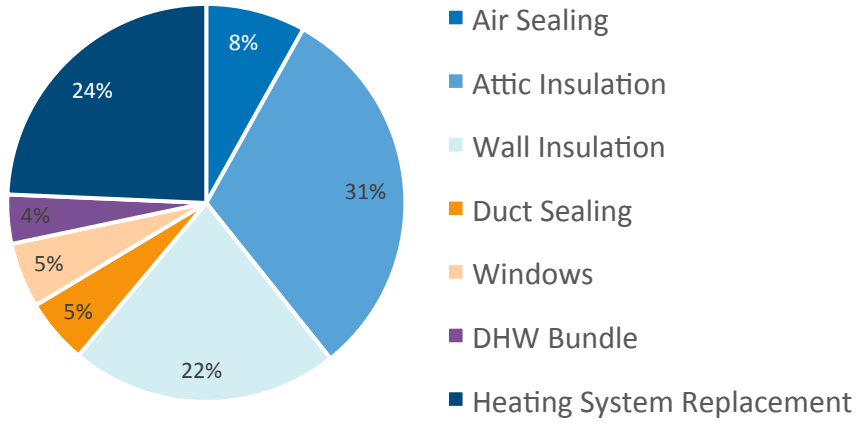


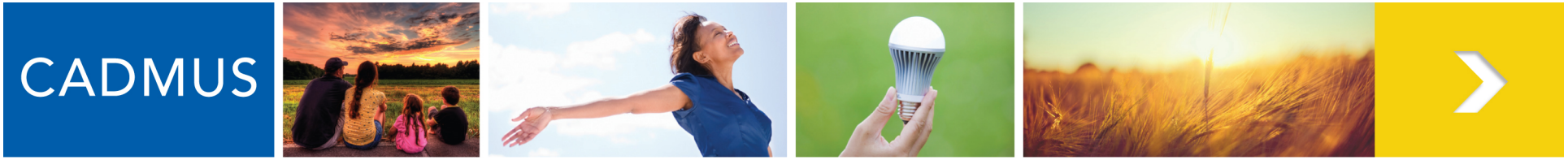
- Higher evaluated savings for attic insulation (129% RR), lower for air sealing (61%) and DHW bundle (72%)
  - Represent highest portion of program savings (89%)
- Program-level RR: 55%



Section 2 – Findings: HES-IE Oil/Propane

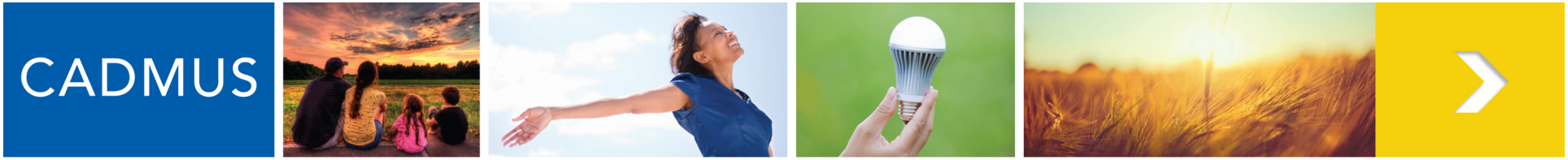
Category	Measures	Average Evaluated Gross Savings (CCF)	Oil		Propane	
			Conversion Factor (gallons/CCF)	Oil Savings per Participant (Gallons)**	Conversion Factor (gallons/CCF)	Propane Savings per Participant (Gallons)
Shell and Duct*	Air Sealing	36	0.7419	26	1.1267	41
	Attic Insulation	139		100		156
	Wall Insulation	96		70		109
	Duct Sealing	24		17		27
	Windows	23		17		26
DHW	Showerhead	7.4		5.5		8.4
	Faucet Aerators	3.0		2.2		3.4
	Pipe Insulation	3.0		2.2		3.4
	Water Heater Temp Setback	4.0		2.9		4.5
HVAC	Heating System Replacement	107		78		121



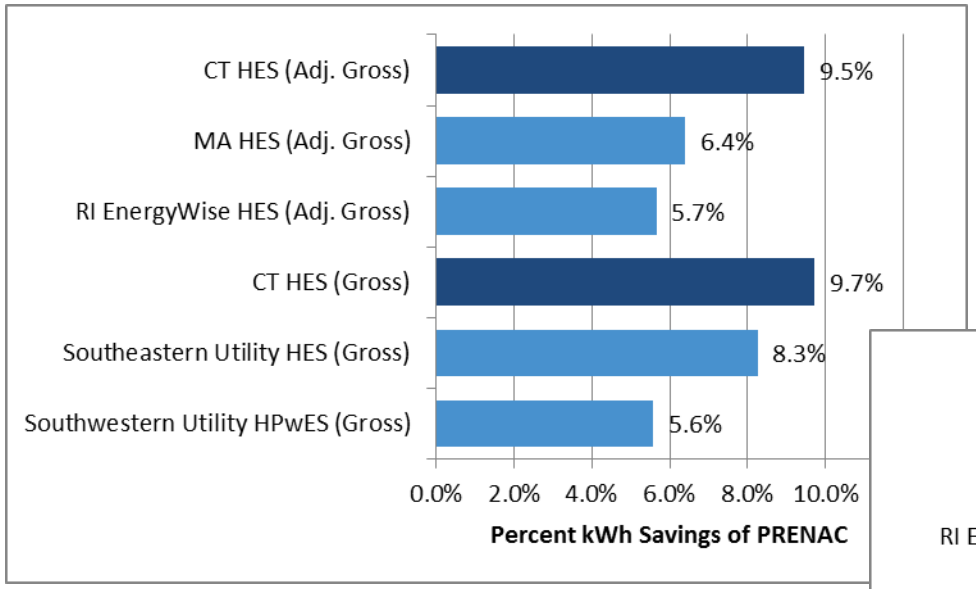


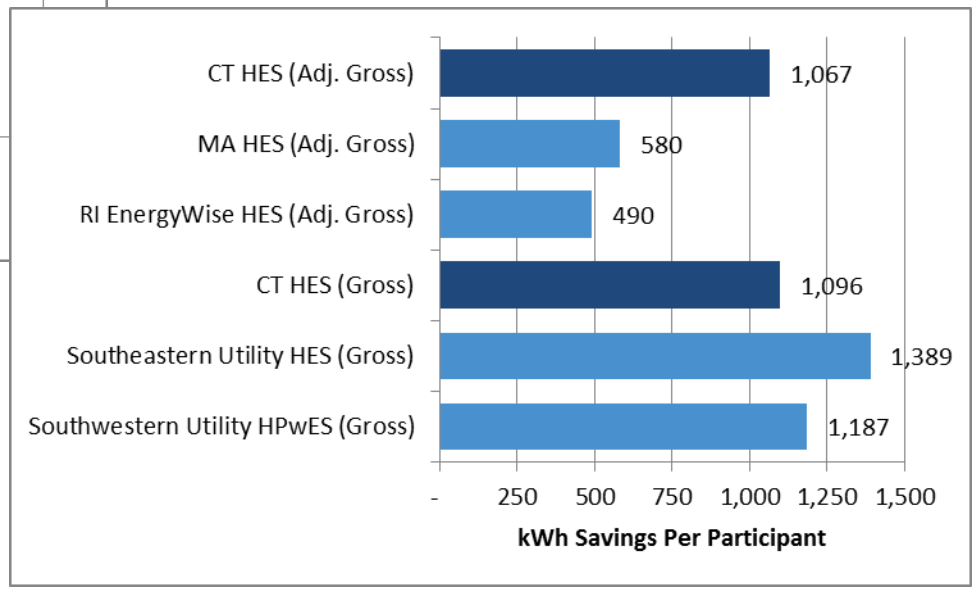
Benchmarking - Section 1 Results

- Compared savings metrics for similar programs in other states
  - Percentage savings
  - kWh savings
- Provided for both gross and adj. gross impacts

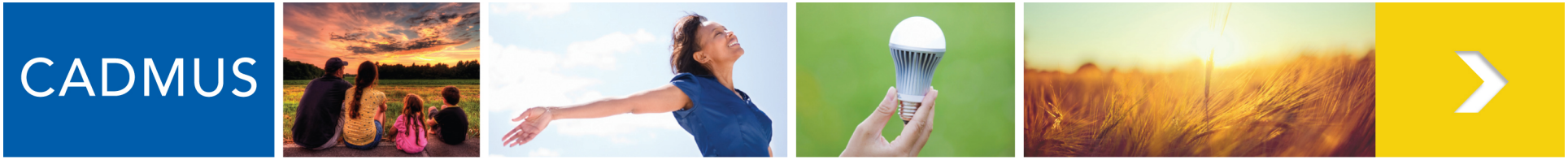


Section 1 – Benchmarking: HES Elec

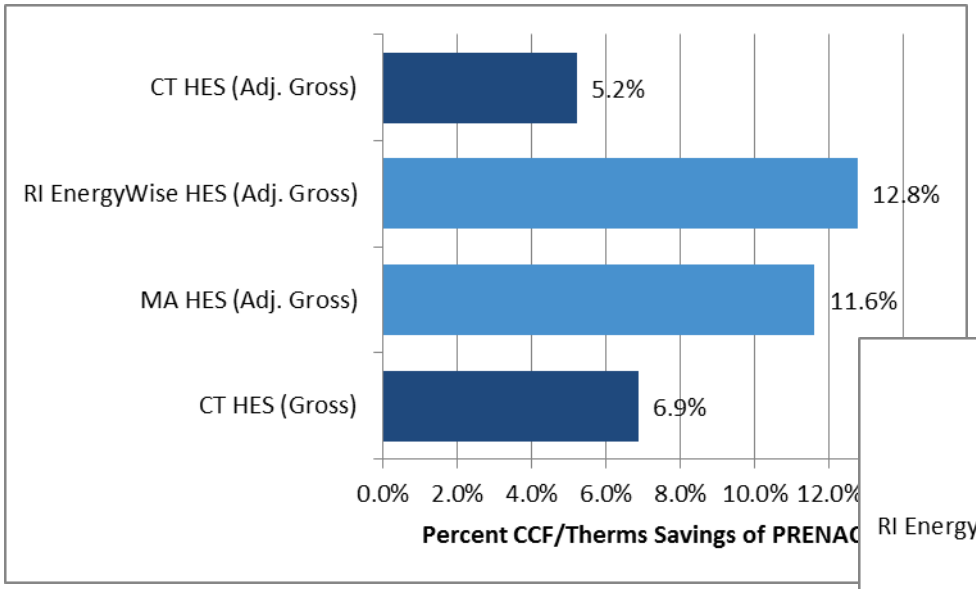


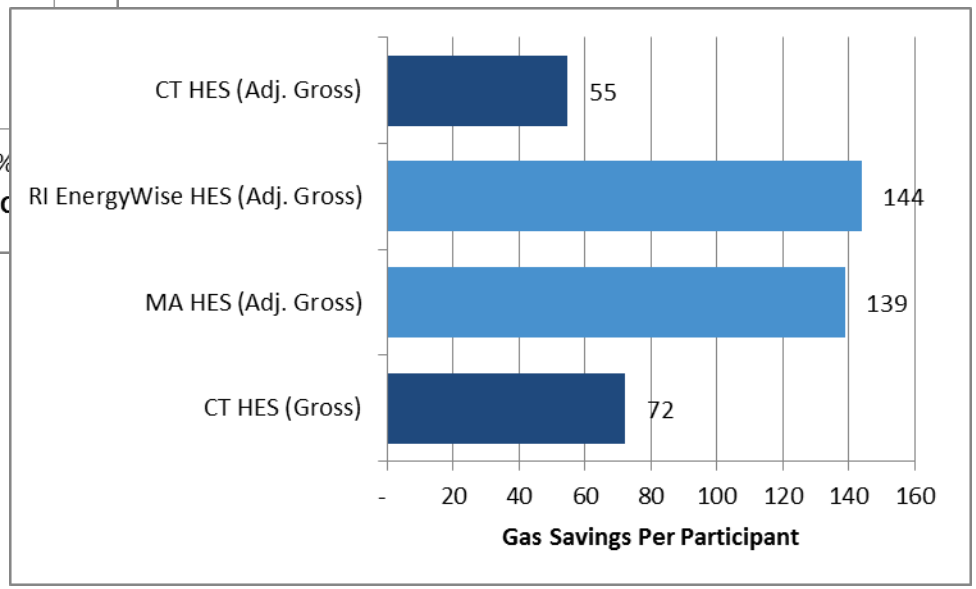


- High % and kWh savings

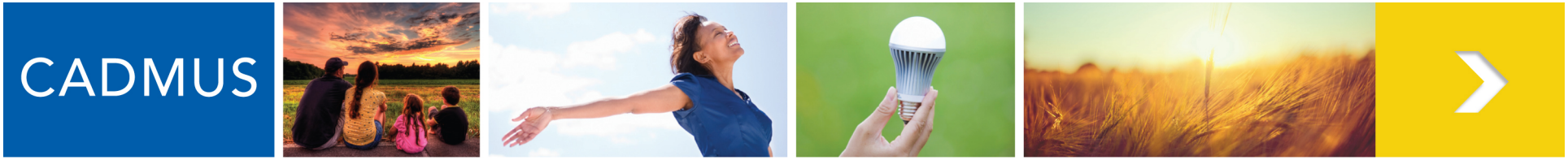


Section 1 – Benchmarking: HES Gas

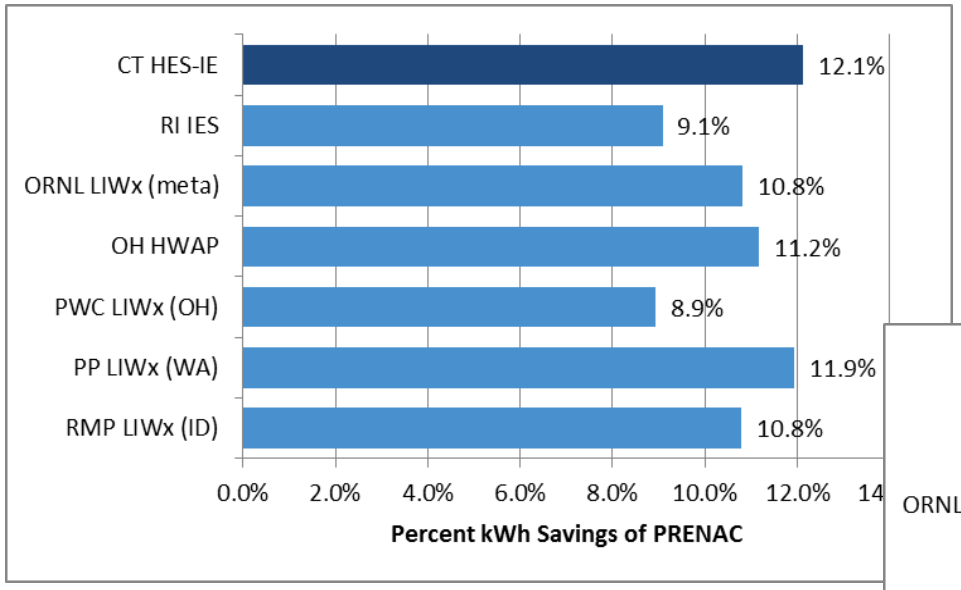


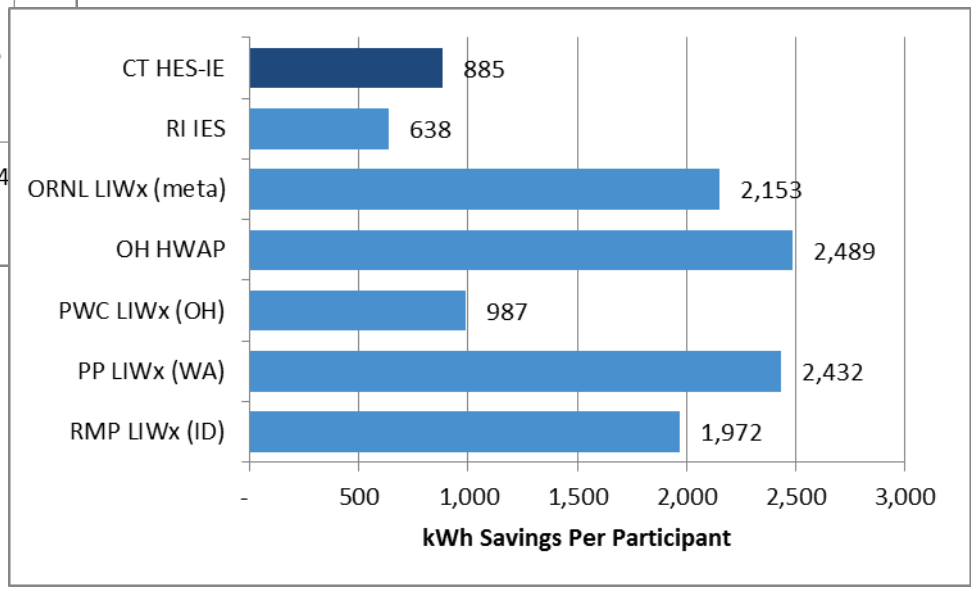


- Lower % and CCF savings
- Other programs have higher freq of high gas-savings measures

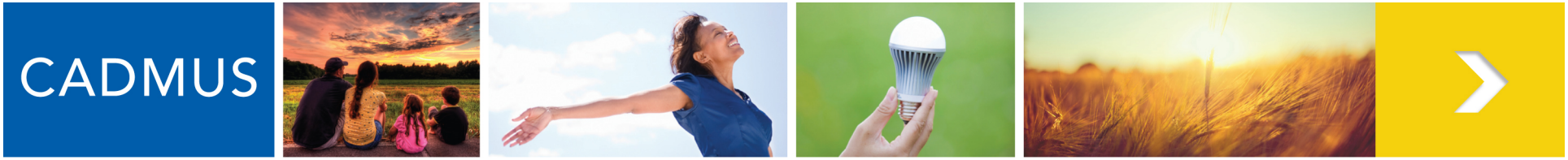


Section 1 – Benchmarking: HES-IE Elec (SP2/SP3)

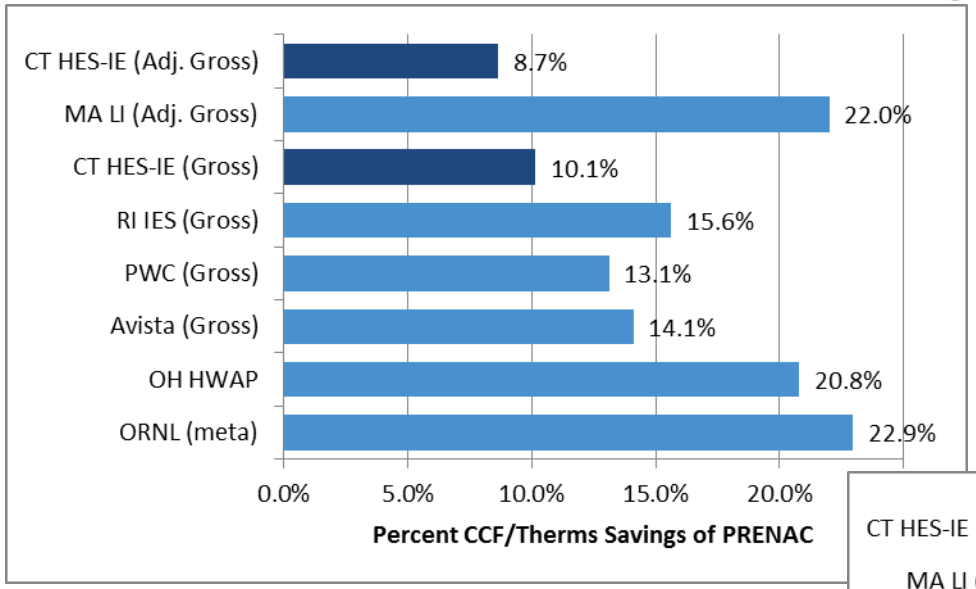


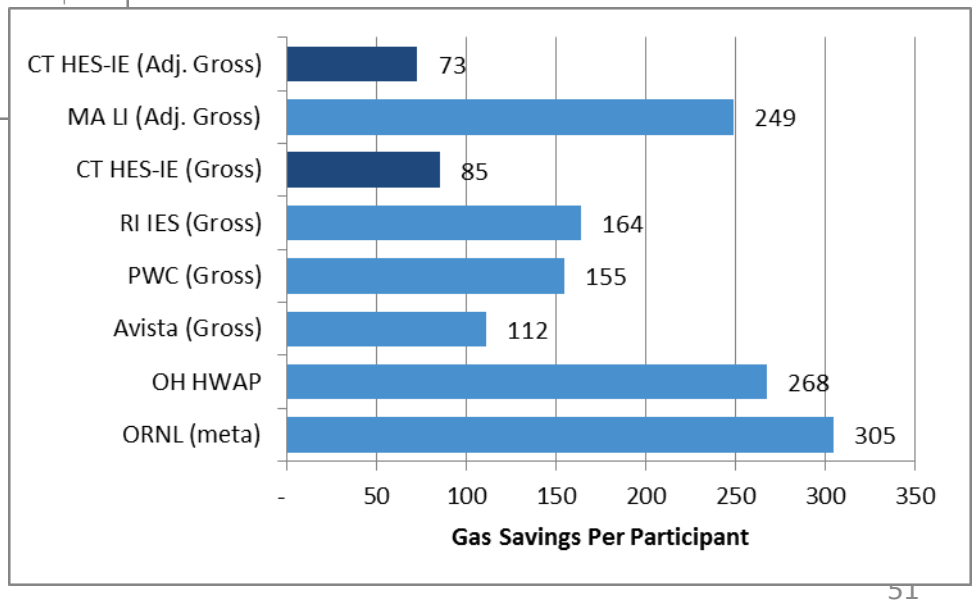


- Highest % savings, modest kWh comparably



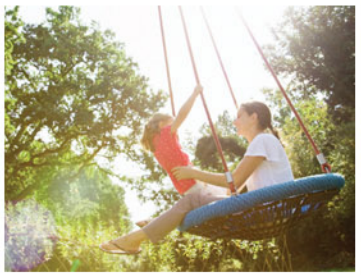
Section 1 – Benchmarking: HES-IE Gas (SP2/SP3)

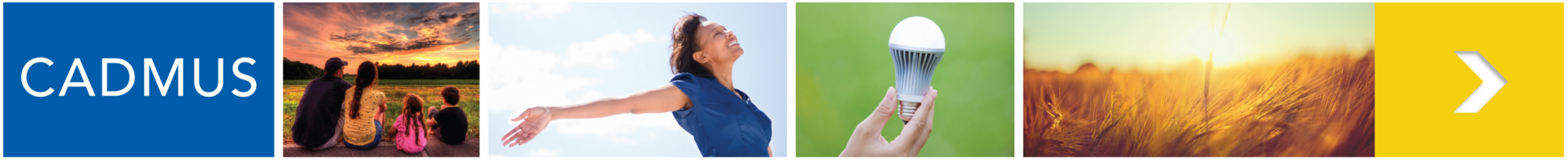




- Lower % and CCF savings
- Other programs have higher freq of high gas-savings measures

Conclusions and Recommendations

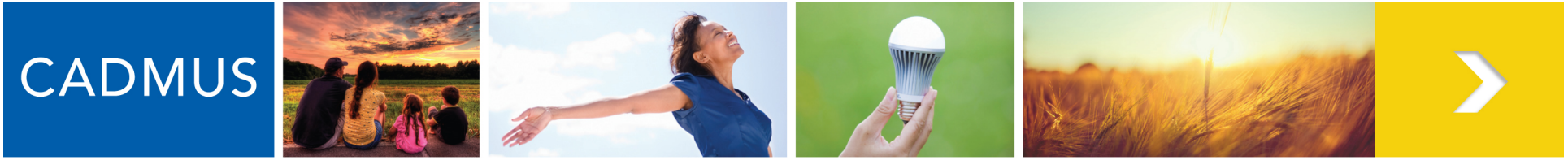




Conclusions and Recommendations

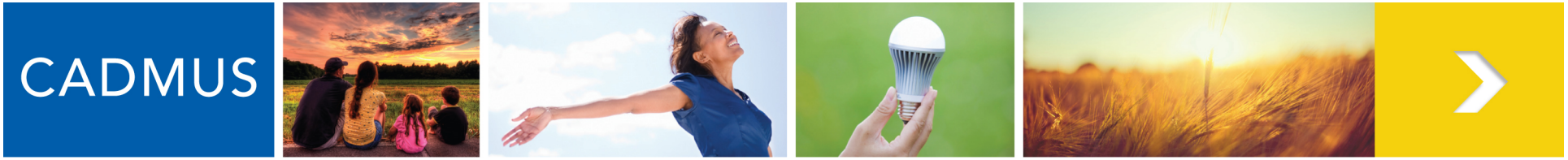
- Consistent ranges of program-level RRs between whole-house vs. measure-level results by program/fuel
  - Within error bounds at 90%, not statistically different*

Program	Electric Savings		Gas Savings	
	Section 1	Section 2	Section 1	Section 2
HES	117%	111%	58%	64%
HES-IE	76%	79%	51%	55%



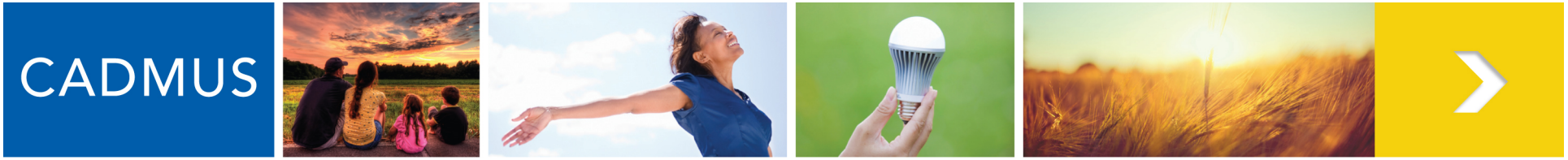
Conclusions and Recommendations

- Key Program-Level Take-Aways:
  - HES and HES-IE electric programs achieved high savings
    - For HES, higher savings achieved through lighting and air sealing than anticipated (resulting in RR>100%)
    - For HES-IE, low RR is not necessarily a bad thing (high % savings points to success) – several implications:
      - Planning estimates
      - Installation / persistence – may relate to quality installation or awareness
  - HES and HES-IE gas programs
    - Lower RRs indicate potential overestimate of *ex ante* savings
    - Lower CCF savings compared to other – due to lower frequencies of high gas-savings measures (e.g., insulation, equip replacement)



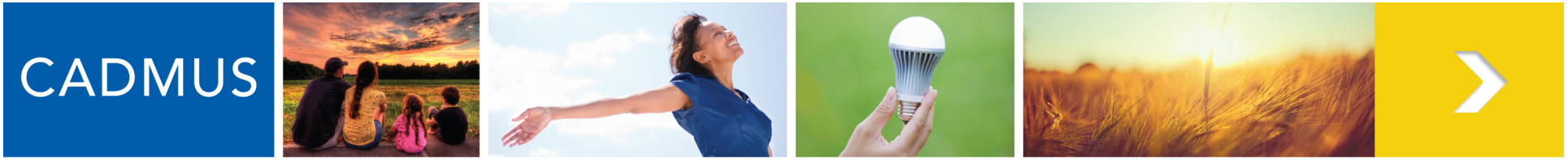
Conclusions and Recommendations

- Measure-Level Considerations:
  - *Ex ante* and evaluated savings confirm highest savings measures – largely consistent for all programs
    - HES-IE Elec showed lower RRs of DHP and DHW bundles, resulting in smaller portions of total savings
  - Nearly 90% of savings occur in top 3-4 measures
    - Elec: Lighting, air sealing, DHW bundle (DHP for HES-IE)
    - Gas: Air sealing, DHW bundle, and Insulation
  - HES Gas / HES-IE Gas
    - Lower measure-level RRs – driven by *ex ante* assumptions or installation



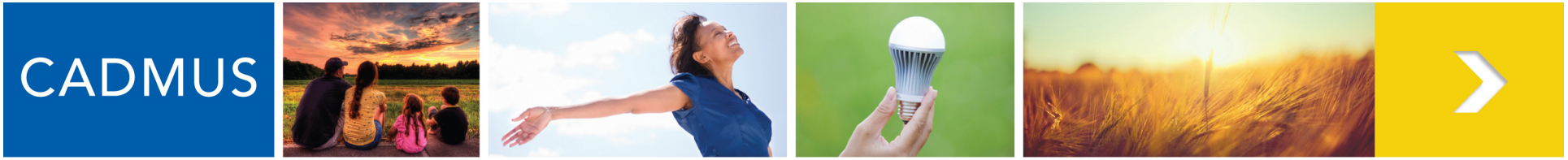
Conclusions and Recommendations

- Measure-specific recommendations:
  - Ductless Heat Pumps – consider more detailed analysis to refine baseline assumptions and key inputs not currently in PSD algorithm
  - Aerators/Showerheads – use water heater recovery efficiency rather than energy factor
  - Pipe Insulation – cap length at six feet
  - Window AC – ensure installations meet minimum efficiency requirements



Conclusions and Recommendations

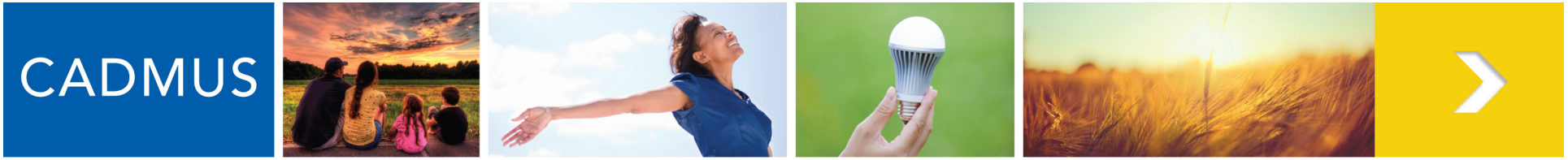
- Data Management – Next Steps:
  - Current Database Improvement Study (R33)
    - Document challenges/concerns in using program tracking data
    - Identify best practice approaches to formats/ structure/ collection to improve evaluability
    - Discuss subsequent changes to CT systems



Conclusions and Recommendations

- Programmatic Implications
  - Ensure no lost opportunities for high-savings measures
    - HES – work to promote add-on measures
      - Regular follow-ups w/ participants
      - Consider incentive levels, financing, marketing materials
      - Demonstrate payback/CE in common terms
    - HES-IE – if CE is issue, look for leveraging opportunities
  - Given savings are focused in 3-4 measures, consider new opportunities to expand HES/HES-IE measure offerings

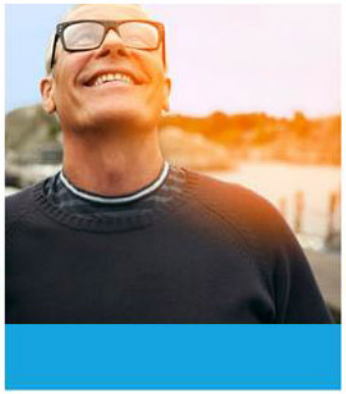
- Data Collection/Tracking Implications
  - Ensure tracking of gas account numbers and key input assumptions (e.g., heating/cooling type)
  - Increased consistency and clarity across and within tracking data will improve usability/evaluability



Conclusions and Recommendations

- PSD Implications
  - Measure RRs highlight instances where actual may deviate from planning
    - Eval savings accounting for actual impacts, different than planning estimates, such as:
      - Installation rate or persistence, effects of energy education / behavior change (e.g., take-back, spillover), actual input assumptions (e.g., HOU)
    - *Ex ante* savings assumptions not aligned w/ actual
      - Tracking system data – accuracy of inputs, such as quantities, efficiencies, fuel types
      - PSD algorithm inputs – e.g., ISRs, kWh/CCF multipliers
      - PSD algorithms
    - Includes DHP, DHW bundle, insulation, air sealing, duct sealing
    - Use RRs and % of program savings to prioritize areas of further research
    - On-site verification and/or process research may help assess areas for QA/QC, lost opportunities, verify input assumptions (e.g., quantities/ efficiencies) and persistence

CADMUS



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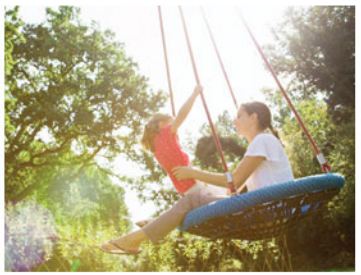
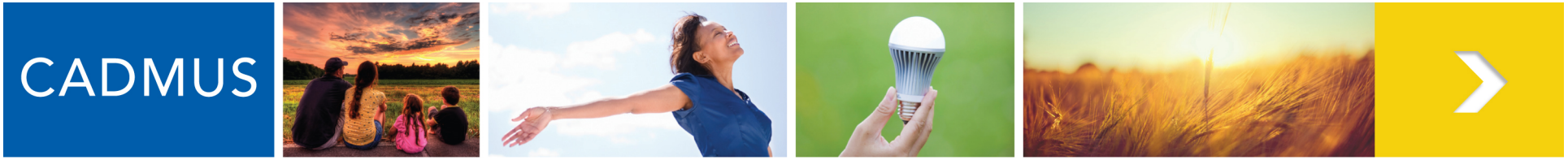
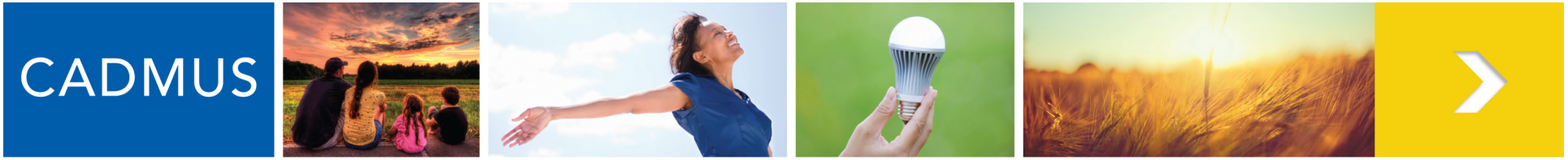
Supplemental Information





Approach: Section 2 – Measure-Level

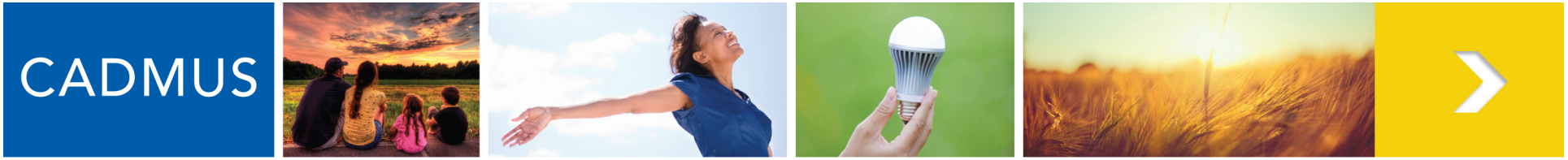
- Lighting interaction adjustment
  - R67 Res Lighting Interactive Effects study completed concurrent with R16
  - Billing analysis results largely account for an array of interactive effects – measure interaction, energy education, behavioral/household changes, take-back, spillover.
  - R16 notes findings from R67 and includes findings in appendix to consider impacts independent of lighting interaction.



Approach: Section 2 – Measure-Level

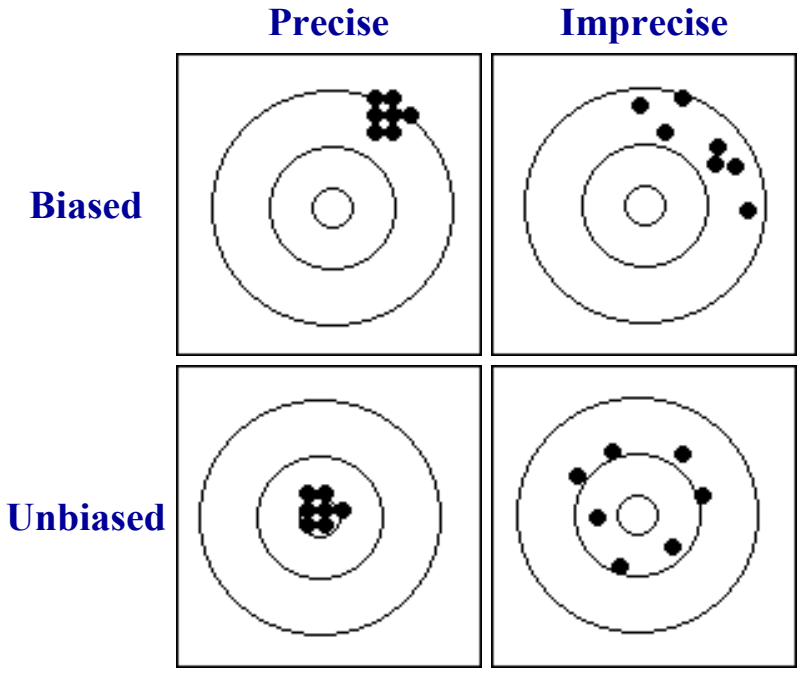
- Lighting interaction adjustment

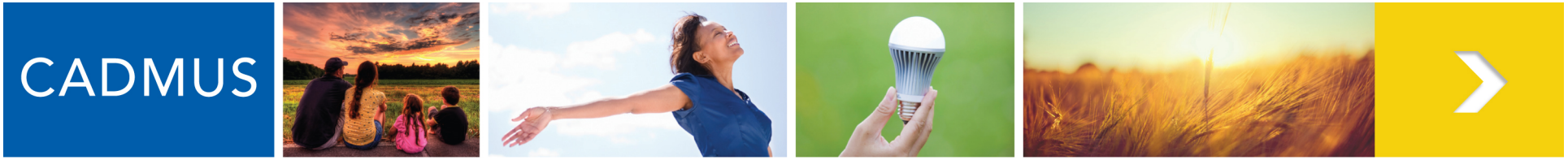
Program	Category	Measure	Reported *Ex ante* Savings (CCF/ HH) (A)	Evaluated Gross Savings (CCF/HH) (B)	Interactive Gas (CCF/ HH) Adjustment (C)	Adjusted Gross Savings (CCF/HH) (D)	Adjusted Realization Rate (D/A)
HES	Shell	Air Sealing	62	57	14.9	71.9	116%
HES-IE	HVAC	Heating System Replacement	128	107	1.4	108.4	85%
HES-IE	Shell	Air Sealing	59	36	7.6	43.6	74%
HES-IE	Shell	Wall Insulation	304	96	3.3	99.3	33%



Approach: Section 2 – Measure-Level

- Rigor = Accuracy (lack of potential bias) + Precision
- Both Matter!





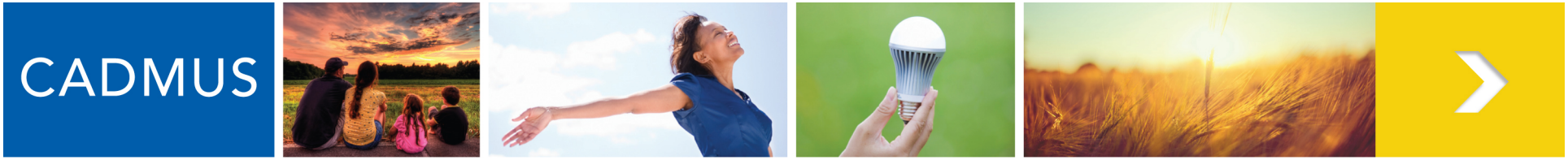
Section 1 – Findings: HES Program-Level Results

HES Electric

Utility	Reported Participation	Reported Savings (MWh)	Evaluated Adjusted Gross Savings (MWh)	Adjusted Gross Realization Rate	Relative Precision at 90% Confidence
CL&P	15,886	16,403	18,977	116%	±4%
UI	5,329	3,588	4,513	126%	±8%
Program Overall	**21,215**	**19,991**	**23,489**	**117%**	**±4%**

HES Gas

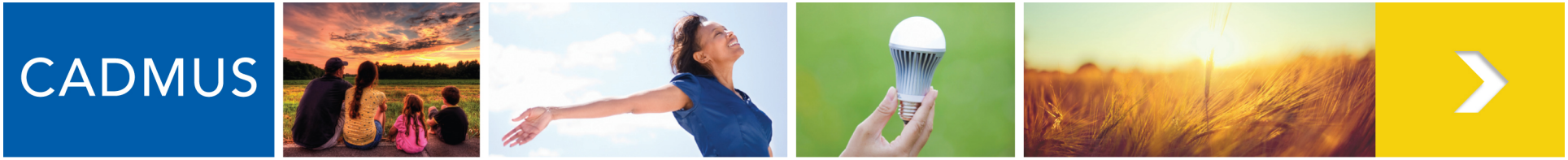
Utility	Reported Participation	Reported Savings (000s CCF)	Evaluated Adjusted Savings (000s CCF)	Adjusted Gross Realization Rate	Relative Precision at 90% Confidence
CNG	1,895	196	132	67%	±17%
SCG	2,369	243	110	45%	±27%
YGS	1,811	172	112	65%	±16%
Program Overall	**6,075**	**611**	**354**	**58%**	**±12%**



Section 1 – Findings: HES Elec

Group	Utility	Model Savings (kWh)	Reported *Ex Ante* Savings (kWh)	Realization Rate	Model Savings as Percentage of Pre-Usage	Reported *Ex Ante* Savings as Percentage of Pre-Usage
Gross savings	CL&P	1,146	936	122%	10%	8%
	UI	972	837	116%	11%	9%
	Overall	**1,096**	**914**	**120%**	**10%**	**8%**
Adjusted gross savings	CL&P	1,082	936	116%	9%	8%
	UI	1,053	837	126%	12%	9%
	Overall	**1,067**	**914**	**117%**	**9%**	**8%**

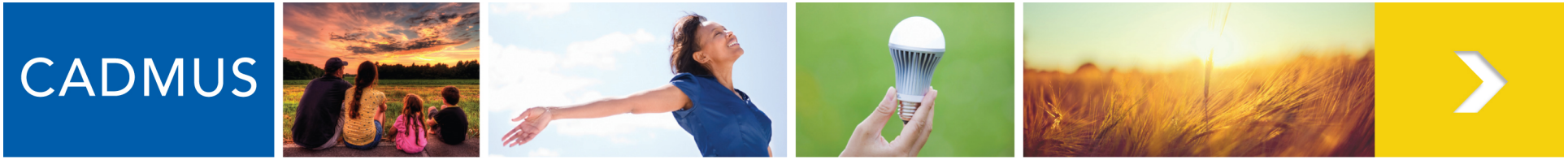
- RR results w/ gross + adj. gross



Section 1 – Findings: HES Elec

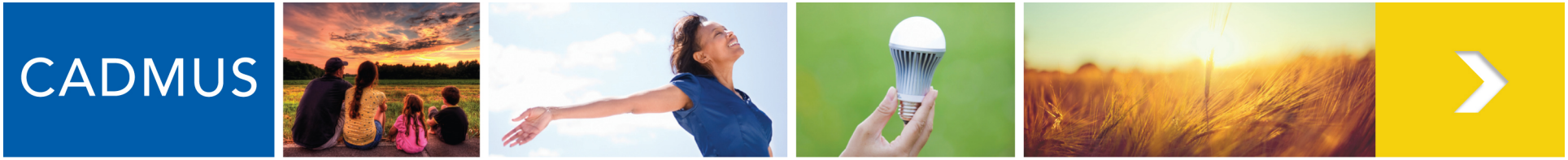
Group	Utility	n	PRENAC	Model Savings (kWh)	Savings as Percentage of Pre-Usage	Relative Precision at 90%
Participant	CL&P	8,695	11,878	1,146	10%	±3%
	UI	2,415	9,159	972	11%	±5%
	Overall	**11,110**	**11,278**	**1,096**	**10%**	**±2%**
Comparison	CL&P	7,043	11,061	59	1%	±61%
	UI	1,504	8,896	-79	-1%	±85%
	Overall	**8,547**	**10,666**	**28**	**0%**	**±112%**
Adjusted gross	CL&P	8,695	11,878	1,082	9%	±4%
	UI	2,415	9,159	1,053	12%	±8%
	Overall	**11,110**	**11,278**	**1,067**	**9%**	**±4%**

- Model Output with PRENAC



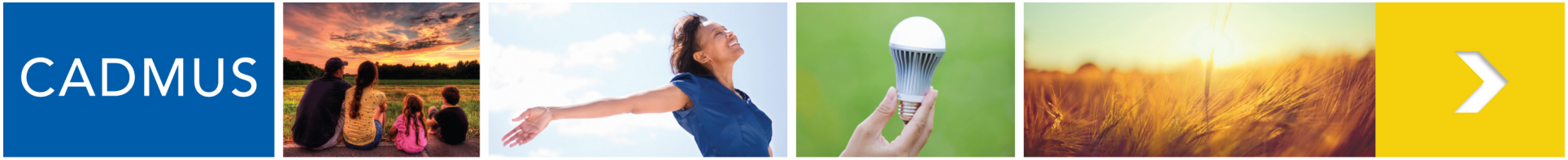
Section 1 – Findings: HES Elec

Category	Measure	Percent of Sample		Average *Ex Ante* Savings by Measure (kWh per Participant)	
		CL&P	UI	CL&P	UI
Lighting	Lighting	97%	97%	661	622
Water Heat	DWH Bundle*	16%	9%	483	477
	Heat Pump Water Heater	<1%	<1%	1,762	1,762
Shell	Air Sealing	76%	67%	163	117
	Attic Insulation	n/a	<1%	n/a	110
	Wall Insulation	n/a	<1%	n/a	90
	Windows	<1%	n/a	482	n/a
	Insulation Other**	4%	n/a	368	n/a
HVAC	Duct Sealing	15%	30%	310	292
	Central AC	1%	4%	230	173
	Heating System Replacement	<1%	<1%	288	293
	Heat Pump	<1%	<1%	1,136	728
	Ductless Heat Pump	<1%	<1%	2,969	2,152
	Ground-Source Heat Pump	<1%	n/a	2,630	n/a
Appliance	Refrigerator	<1%	1%	247	234
	Dehumidifier	<1%	<1%	398	172
	Clothes Washer	<1%	<1%	364	102
	Freezer	<1%	n/a	638	n/a
Other	Other	n/a	<1%	n/a	259
Sample (n)		**8,695**	**2,415**		



Section 1 – Findings: HES Gas

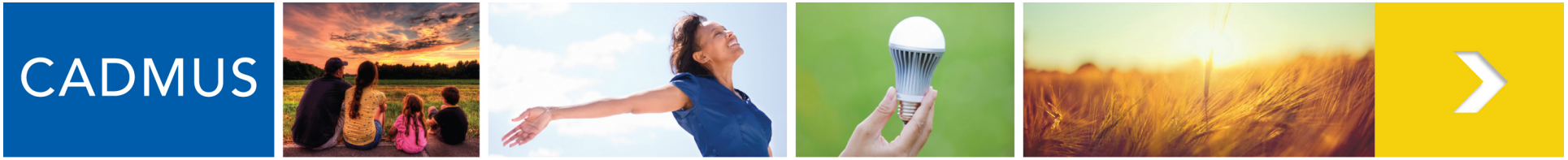
Category	Measure	Percentage of Sample			Average *Ex Ante* Savings by Measure (CCF per Participant)		
		CNG	SCG	YGS	CNG	SCG	YGS
Shell	Air sealing	90%	97%	91%	62	64	61
	Attic insulation	n/a	3%	n/a	n/a	114	n/a
	Wall insulation	n/a	1%	n/a	n/a	287	n/a
	Insulation other	<1%	n/a	<1%	228	n/a	69
	Windows	n/a	n/a	<1%	n/a	n/a	19
Water heating	DWH bundle*	81%	78%	76%	30	26	27
HVAC	Duct sealing	12%	26%	15%	42	48	53
	Heating system replacement	<1%	<1%	<1%	304	282	171
Appliance	Clothes washer	n/a	<1%	n/a	n/a	8	n/a
Sample (n)		**649**	**461**	**752**			



Section 1 – Findings: HES Gas

Group	Utility	Model Savings (CCF)	Reported *Ex Ante* Savings (CCF)	Realization Rate	Model Savings as Percentage of Pre-Usage	Reported *Ex Ante* Savings as Percentage of Pre-Usage
Gross savings	CNG	76	88	86%	7%	8%
	SCG	61	103	59%	6%	10%
	YGS	76	85	89%	8%	9%
	Overall	**72**	**91**	**80%**	**7%**	**9%**
Adjusted gross savings	CNG	59	88	67%	5%	8%
	SCG	46	103	45%	4%	10%
	YGS	55	85	65%	6%	9%
	Overall	**55**	**91**	**60%**	**5%**	**9%**

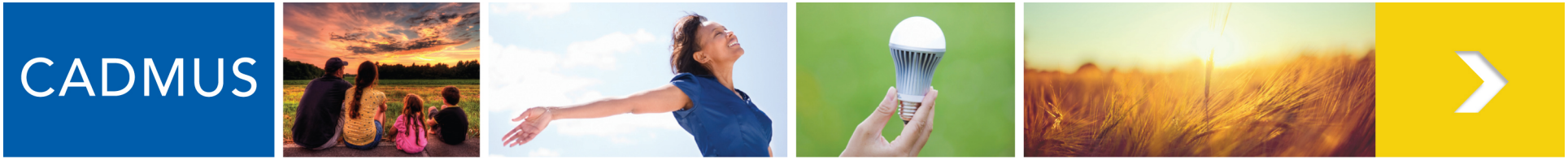
- RR results w/ gross + adj. gross



Section 1 – Findings: HES Gas

Group	n	PRENAC	Model Savings (CCF)	Savings as Percentage of Pre-Usage	Relative Precision at 90%	Savings Lower 90% (CCF)	Savings Upper 90% (CCF)
Participants	1,862	1,051	72	7%	±6%	68	76
Comparison	1,192	999	17	2%	±25%	12	21
Adjusted gross	1,862	1,051	55	5%	±12%	48	61

- Model Output with PRENAC



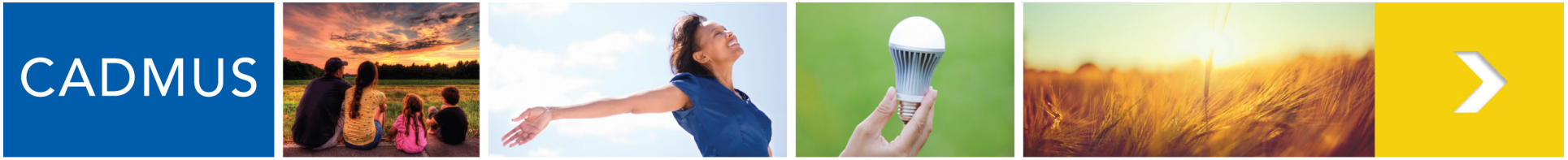
Section 1 – Findings:
HES-IE Program-Level Results

HES-IE Electric

Utility	Reported Participation	Reported Savings (MWh)	Evaluated Adjusted Gross Savings (MWh)	Adjusted Gross Realization Rate	Relative Precision at 90% Confidence
CL&P Overall	**10,685**	**19,959***	**13,600**	**68%****	**±7%**
CL&P—SP1	n/a	2,441	2,052	84%	±20%
CL&P—SP2/SP3		12,157	8,295	68%	±6%
CL&P—SP4		5,362	3,253	61%	±23%
UI	**5,612**	**5,173**	**5,414**	**105%**	**±6%**
Program Overall	**16,297**	**25,132**	**19,014**	**76%**	**±6%**

HES-IE Gas

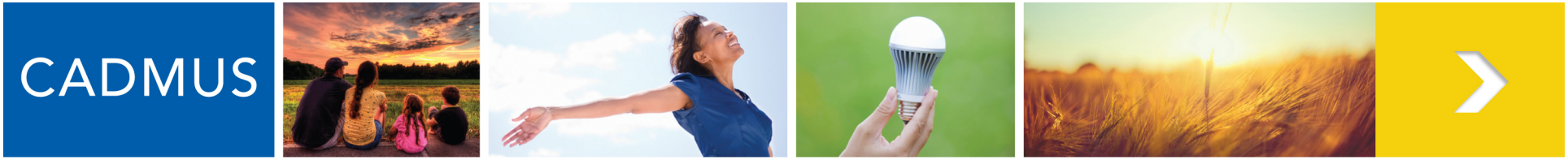
Utility	Reported Participation	Reported Savings (000s CCF)	Evaluated Adjusted Gross Savings (000s CCF)	Adjusted Gross Realization Rate	Relative Precision at 90% Confidence
CNG Overall	**1,610**	**211**	**102**	**49%**	**±20%**
CNG—SP1	n/a	24	20	83%	±30%
CNG—SP2/SP3		174	76	44%	±25%
CNG—SP4		13	6	47%	±61%
SCG	**3,268**	**361**	**206**	**57%**	**±23%**
YGS Overall	**1,961**	**360**	**165**	**46%**	**±25%**
YGS—SP1	n/a	18	9	51%	±38%
YGS—SP2/SP3		283	132	47%	±25%
YGS—SP4		59	24	41%	±97%
Program Overall	**6,839**	**932**	**474**	**51%**	**±14%**



Section 1 – Findings: HES-IE Elec (SP2/SP3)

Group	Utility	Model Savings (kWh)	Reported *Ex Ante* Savings (kWh)	Realization Rate	Model Savings as Percentage of Pre-Usage	Reported *Ex Ante* Savings as Percentage of Pre-Usage
Gross savings	CL&P	917	1,481	62%	12%	20%
	UI	864	966	89%	12%	14%
	Overall	**885**	**1,281**	**69%**	**12%**	**18%**
Adjusted gross savings	CL&P	1,011	1,481	68%	14%	20%
	UI	1,011	966	105%	14%	14%
	Overall	**1,005**	**1,281**	**78%**	**14%**	**18%**

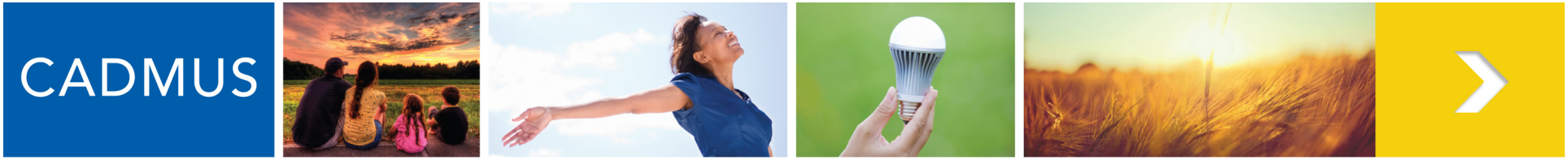
- RR results w/ gross + adj. gross



Section 1 – Findings: HES-IE Elec (SP2/SP3)

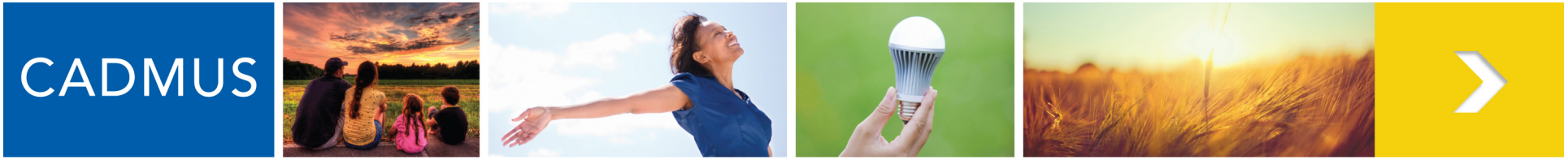
Group	Utility	n	PRENAC	Model Savings (kWh)	Savings as Percentage of Pre-Usage	Relative Precision at 90%
Participants	CL&P	3,196	7,408	917	12%	±6%
	UI	2,285	7,111	864	12%	±5%
	Overall	**5,481**	**7,292**	**885**	**12%**	**±4%**
Comparison	CL&P	4,016	6,367	-80	-1%	±43%
	UI	1,414	5,204	-108	-2%	±46%
	Overall	**5,430**	**6,091**	**-100**	**-2%**	**±29%**
Adjusted gross	CL&P	3,196	7,408	1,011	14%	±6%
	UI	2,285	7,111	1,011	14%	±6%
	Overall	**5,481**	**7,292**	**1,005**	**14%**	**±5%**

- Model Output with PRENAC



Section 1 – Findings: HES-IE Elec (SP2/SP3)

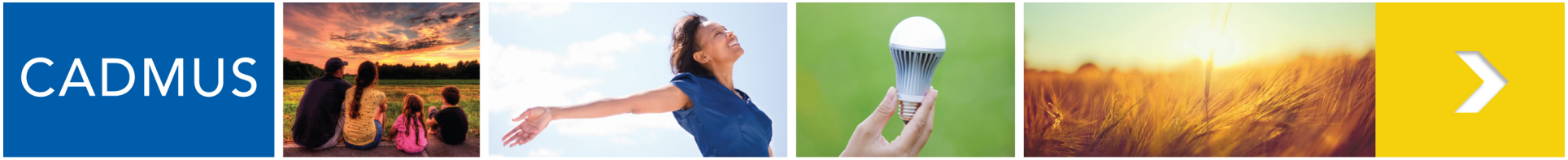
Category	Measure	Percentage of Sample		Average *Ex Ante* Savings by Measure (kWh per Participant)	
		CL&P	UI	CL&P	UI
Lighting	Lighting	84%	96%	503	419
Water heat	DWH bundle *	40%	21%	565	697
	Water heater replacement	3%	n/a	55	n/a
Shell	Air sealing	32%	53%	514	380
	Attic insulation	9%	2%	433	2,565
	Wall insulation	2%	<1%	1,493	1,440
	Insulation other **	2%	n/a	153	n/a
	Windows	2%	n/a	532	n/a
HVAC	Ductless heat pump	21%	7%	1,717	1,805
	Duct sealing	<1%	4%	284	255
	Window AC	4%	n/a	98	n/a
	Central AC	n/a	<1%	n/a	98
Appliance	Refrigerator	26%	n/a	758	n/a
	Appliance other ***	n/a	13%	n/a	353
	Freezer	3%	n/a	733	n/a
Other	Other	<1%	n/a	637	n/a
Sample (n)		**3,196**	**2,285**		



Section 1 – Findings: HES-IE Gas (SP2/SP3)

Group	Utility	Model Savings (CCF)	Reported *Ex Ante* Savings (CCF)	Realization Rate	Model Savings as Percentage of Pre-Usage	Reported *Ex Ante* Savings as Percentage of Pre-Usage
Gross savings	CNG	90	152	59%	9%	16%
	SCG	68	124	55%	7%	14%
	YGS	92	161	57%	13%	23%
	Overall	**85**	**149**	**57%**	**10%**	**18%**
Adjusted gross savings	CNG	67	152	44%	7%	16%
	SCG	71	124	57%	8%	14%
	YGS	75	161	47%	11%	23%
	Overall	**73**	**149**	**49%**	**9%**	**18%**

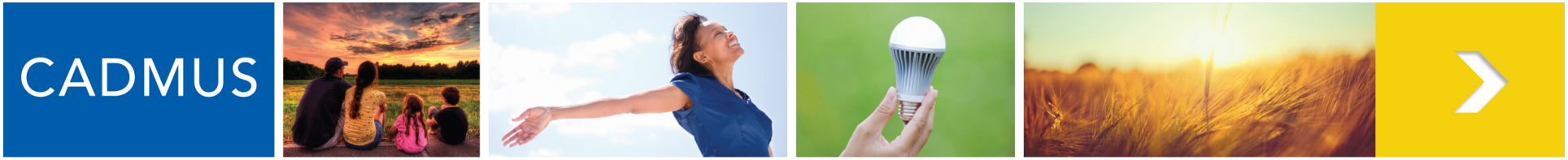
- RR results w/ gross + adj. gross



Section 1 – Findings: HES-IE Gas (SP2/SP3)

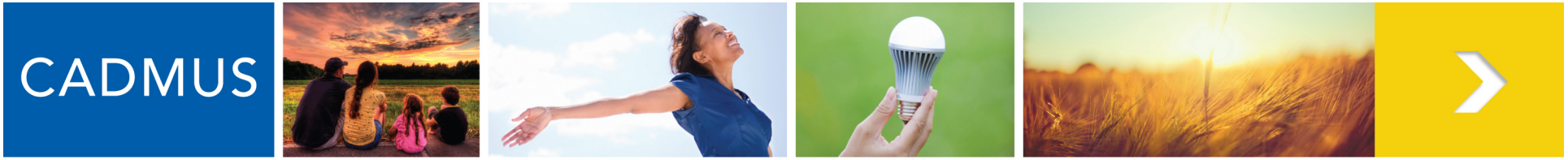
Group	Utility	n	PRENAC	Model Savings (CCF)	Savings as Percentage of Pre-Usage	Relative Precision at 90%
Participant	CNG	460	976	90	9%	±10%
	SCG	340	903	68	7%	±17%
	YGS	450	713	92	13%	±14%
	Overall	**1,250**	**840**	**85**	**10%**	**±10%**
Comparison	CNG	223	981	23	2%	±62%
	SCG	233	928	-3	0%	±366%
	YGS	188	756	18	2%	±76%
	Overall	**644**	**873**	**13**	**1%**	**±62%**
Adjusted gross	CNG	460	976	67	7%	±25%
	SCG	340	903	71	8%	±23%
	YGS	450	713	75	11%	±25%
	Overall	**1,250**	**840**	**73**	**9%**	**±16%**

- Model Output with PRENAC



Section 1 – Findings: HES-IE Gas (SP2/SP3)

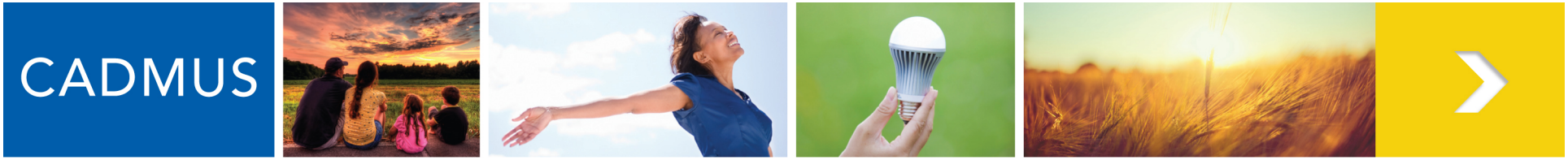
Category	Measure	Percentage of Sample			Average *Ex Ante* Savings by Measure (CCF per Participant)		
		CNG	SCG	YGS	CNG	SCG	YGS
Shell	Air sealing	77%	96%	68%	69	66	45
	Attic insulation	5%	4%	26%	287	204	135
	Wall insulation	12%	3%	22%	373	477	251
	Windows	2%	n/a	5%	4	n/a	63
Water heating	DWH bundle*	82%	90%	63%	43	38	37
	Water heater temp setback	32%	<1%	5%	6	6	6
HVAC	Duct sealing	n/a	10%	<1%	n/a	49	29
	Heating system replacement	<1%	n/a	12%	267	n/a	127
Appliance	Appliance other	n/a	1%	n/a	n/a	8	n/a
Other	Other	<1%	n/a	1%	130	n/a	8
Sample (n)		**460**	**340**	**450**			



Section 1 – Findings: HES-IE Elec(SP1/SP4)

HES-IE Subprogram	Group	n	PRENAC	Model Savings (kWh)	Savings as Percentage of Pre-Usage	Relative Precision at 90%	Savings Lower 90% (kWh)	Savings Upper 90% (kWh)
SP1*	Participant	1,348	8,708	765	9%	±7%	711	819
	Comparison	197	8,841	-314	-4%	±66%	-522	-107
	Adjusted gross	1,348	8,708	1,074	12%	±20%	860	1,289
SP4	Participant	2,670	6,617	458	7%	±7%	426	491
	Comparison	256	6,181	-160	-3%	±87%	-298	-21
	Adjusted gross	2,670	6,617	629	10%	±23%	487	772

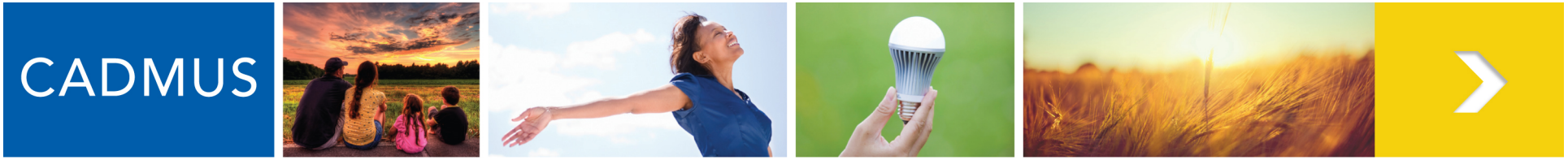
- Model Output with PRENAC



Section 1 – Findings: HES-IE Elec (SP1/SP4)

Category	Measure	Percentage of Sample		Average *Ex Ante* Savings by Measure (kWh per Participant)	
		SP1	SP4**	SP1	SP4**
Lighting	Lighting	93%	96%	712	403
Water Heat	DHW Bundle*	26%	77%	793	812
	Pipe Insulation	4%	<1%	115	62
	Water Heater Setback	5%	<1%	86	86
Shell	Air Sealing	7%	5%	1,635	604
	Attic Insulation	2%	n/a	638	n/a
	Wall Insulation	<1%	n/a	2,339	n/a
	Windows	<1%	n/a	231	n/a
HVAC	Window AC	<1%	<1%	56	29
Appliances	Freezer	5%	n/a	877	n/a
	Refrigerator	23%	4%	985	806
Other	Other	<1%	n/a	554	n/a
Sample (n)		**1,348**	**2,670**		

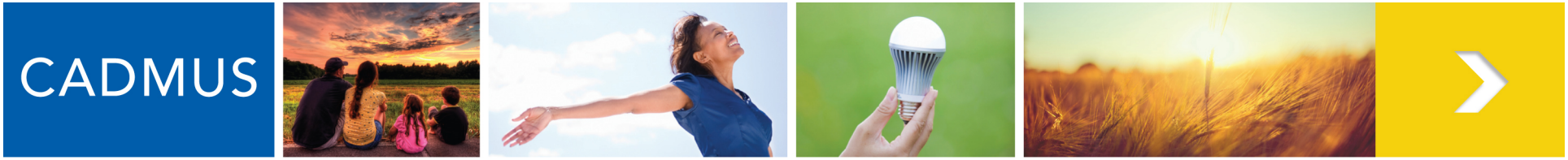
- Higher frequency of core measures: lighting (93-96%), DHW bundle (26-77%)
  - SP1 showed higher refrigerator replacement (23%)
- Nonparticipant usage increase ranging from 160 kWh (SP4) to 314 kWh (SP1), consistent trend seen in SP2/SP3



Section 1 – Findings: HES-IE Gas (SP1/SP4)

HES-IE Subprogram	Group	n	PRENAC	Model Savings (CCF)	Savings as Percentage of Pre-Usage	Relative Precision at 90%	Savings Lower 90% (CCF)	Savings Upper 90% (CCF)
SP1	Participants	231	1,006	97	10%	±15%	83	111
	Comparison**	664	873	13	1%	±62%	5	21
	Adjusted gross	231	1,006	82	8%	±20%	66	99
SP4	Participants	114	723	43	6%	±39%	26	59
	Comparison**	664	873	13	1%	±62%	5	21
	Adjusted gross	114	723	32	4%	±58%	13	51

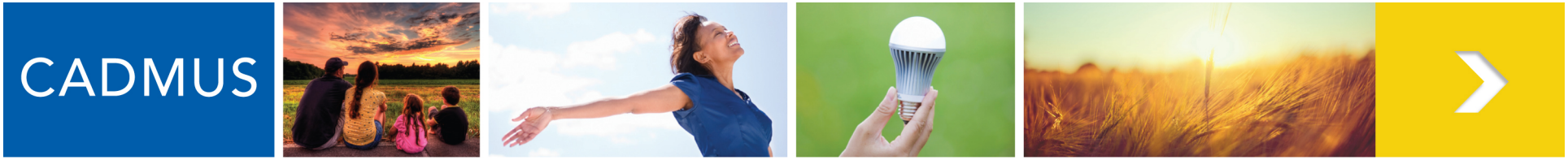
- Model Output with PRENAC



Section 1 – Findings: HES-IE Gas (SP1/SP4)

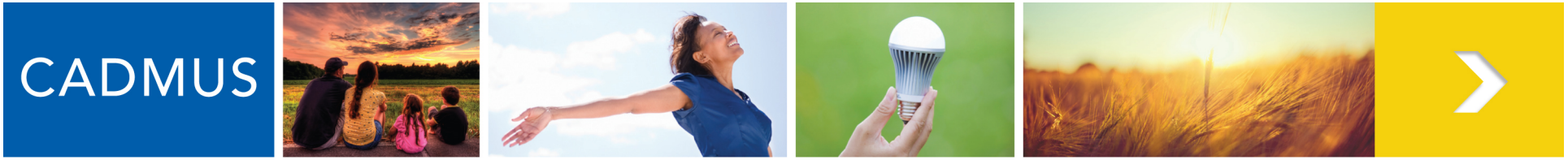
Category	Measure	Percentage of Sample		Average *Ex Ante* Savings by Measure (CCF per Participant)	
		SP1	SP4**	SP1	SP4**
Shell	Air Sealing	63%	42%	57	40
	Attic Insulation	11%	n/a	41	n/a
	Wall Insulation	6%	n/a	127	n/a
	Windows	4%	n/a	7	n/a
Water Heat	DHW Bundle*	77%	96%	41	41
	Pipe Insulation	18%	3%	5	10
	Water Heater Setback	12%	n/a	6	n/a
HVAC	Heating System Replacement	3%	n/a	318	n/a
Other	Other	3%	n/a	35	n/a
Sample (n)		**231**	**114**		

- Higher frequency of core measures: air sealing (42-63%), DHW bundle (77-96%)
  - SP1 attic insulation (11%)
- Nonparticipant decrease usage (13 CCF), consistent trend seen in SP2/SP3 (CNG/ YGS)



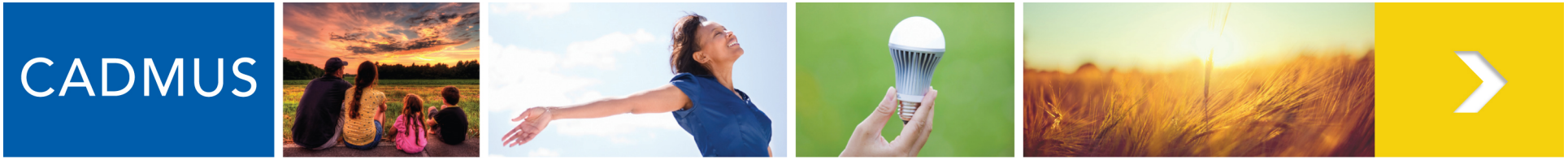
Section 2 – Findings: HES Program-Level Results

Value	Annual MWh	Annual kW	Annual CCF (000s)
Reported Savings	19,991	3,413	569
Evaluated Adjusted Savings	22,110	3,774	382
Adj. Gross Realization Rate		111%	64%



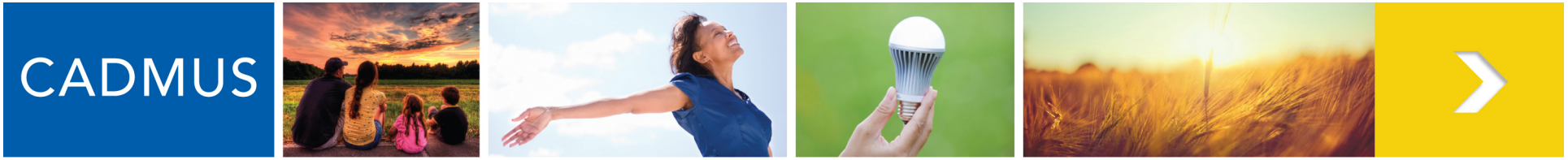
Section 2 – Findings:
HES-IE Program-Level Results

Value	Annual MWh	Annual kW	Annual CCF (000s)
Reported Savings	25,132	1,558	932
Evaluated Adjusted Savings	19,950	1,237	513
Adj. Gross Realization Rate**		79%	55%



Conclusions and Recommendations

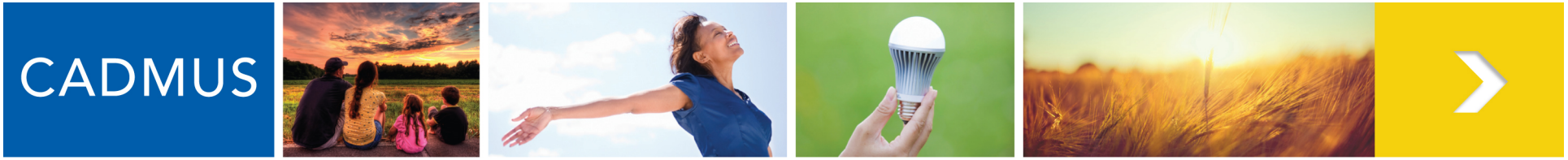
- Data Management
  - Consistency between and within utility tracking systems
    - Consistent terminologies (e.g., measure names/description)
    - Collecting key attribute inputs (e.g., building types, heating fuels)
  - Database QA procedures
    - Consistency in conditioned sqft across different files for same project
    - Standardized values, consistently populated (e.g., differentiate between n/a vs. blank vs. 0)
    - Input validation (e.g,. Installed sqft < total building sqft)
  - Instances where measure-specific inputs required for PSD calculations were missing



Conclusions and Recommendations

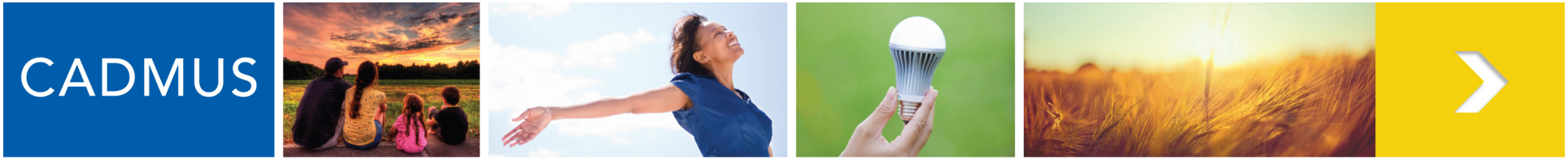
- Data Management (cont.)
  - MF building reporting – consistent reporting at unit level, easily mapped to bill data (at facility level) using unique ID.
  - Challenges in identifying measures attributed to HES/HES-IE vs. other changing initiatives
  - Ensure tracking of both electric and gas account numbers
    - Challenges in linking program tracking to billing data

- Current Database Improvement Study (R33)
  - Addressing challenges, best practice, and recommended changes



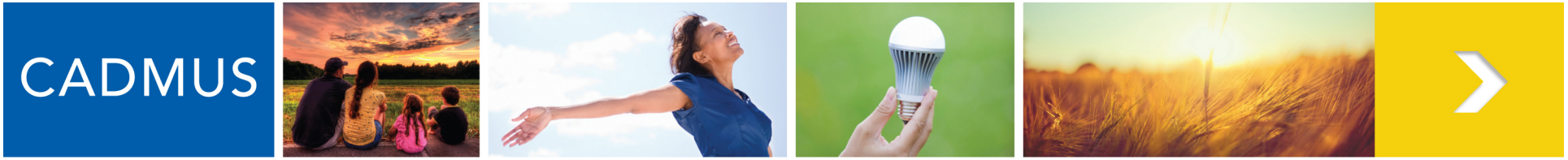
Modeling Approach - Attrition: HES Elec Participants

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original electric accounts	19,320	100%	0	0%
Matched to billing data provided	17,348	90%	1,972	10%
Insufficient pre- and post-period months	15,308	79%	2,040	11%
Changed usage from the pre to post (> 70%)	15,240	79%	68	0%
Ex ante savings higher than pre-usage, or *ex ante* savings <1% of pre-usage	14,946	77%	294	2%
Pre- or post-period usage less than 1000 kWh	14,937	77%	9	0%
PRISM screen: wrong signs on PRISM parameters	14,872	77%	65	0%
Account-level inspection of pre/post 12-month usage (e.g., vacancies, anomalies)	11,110	58%	3,762	19%
Final analysis group	**11,110**	**58%**	**8,210**	**42%**



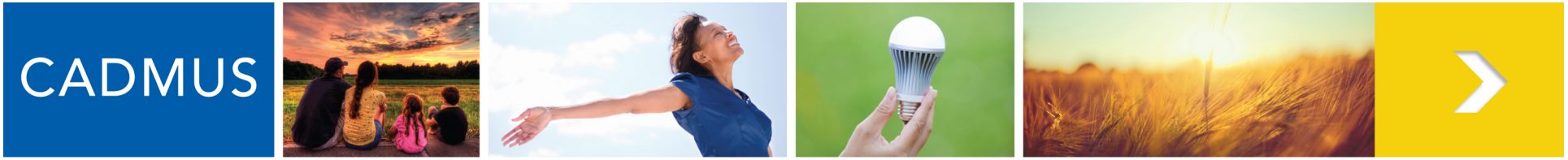
Modeling Approach - Attrition: HES Gas Participants

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original gas accounts	4,922	100%	0	0%
Matched to billing data provided	2,718	55%	2,204	45%
Insufficient pre- and post-period months	2,369	48%	349	7%
Changed usage from the pre to post (> 70%)	2,346	48%	23	0%
Ex ante savings higher than pre-usage, or *ex ante* savings <1% of pre-usage	2,145	44%	201	4%
Pre- or post-period usage less than 200 therms	2,071	42%	74	2%
PRISM screen: wrong signs on PRISM parameters	2,028	41%	43	1%
Account-level inspection of pre/post 12-month usage (e.g., vacancies, anomalies)	1,862	38%	166	3%
Final analysis group	**1,862**	**38%**	**3,060**	**62%**



Modeling Approach - Attrition: HES-IE Elec Participants (SP2/SP3)

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original electric accounts	11,577	100%	0	0%
Matched to billing data provided	11,395	98%	182	2%
Insufficient pre- and post-period months	8,378	72%	3,017	26%
Changed usage from the pre to post (> 70%)	8,325	72%	53	0%
Ex ante savings higher than pre-usage, or *ex ante* savings <1% of pre-usage	7,815	68%	510	4%
Pre- or post-period usage less than 1000 kWh	7,782	67%	33	0%
PRISM screen: wrong signs on PRISM parameters	7,705	67%	77	1%
Account-level inspection of pre/post 12-month usage (e.g., vacancies, anomalies)	5,481	47%	2,224	19%
Final analysis group	**5,481**	**47%**	**6,096**	**53%**



Modeling Approach - Attrition: HES-IE Gas Participants (SP2/SP3)

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original gas accounts	5,120	100%	0	0%
Matched to billing data provided	2,374	46%	2,746	54%
Insufficient pre- and post-period months	1,872	37%	502	10%
Changed usage from the pre to post (> 70%)	1,864	36%	8	0%
Ex ante savings higher than pre-usage, or *ex ante* savings <1% of pre-usage	1,529	30%	335	7%
Pre; or post-period usage less than 200 therms	1,480	29%	49	1%
PRISM screen: wrong signs on PRISM parameters	1,446	28%	34	1%
Account-level inspection of pre/post 12-month usage (e.g., vacancies, anomalies)	1,250	24%	196	4%
Final analysis group	**1,250**	**24%**	**3,870**	**76%**