OREGON HOUSING & COMMUNITY SERVICES

Multifamily Energy Program

ENERGY MODELING BEST PRACTICES

Date: August 23, 2018

Presenters: Mekha Abraham

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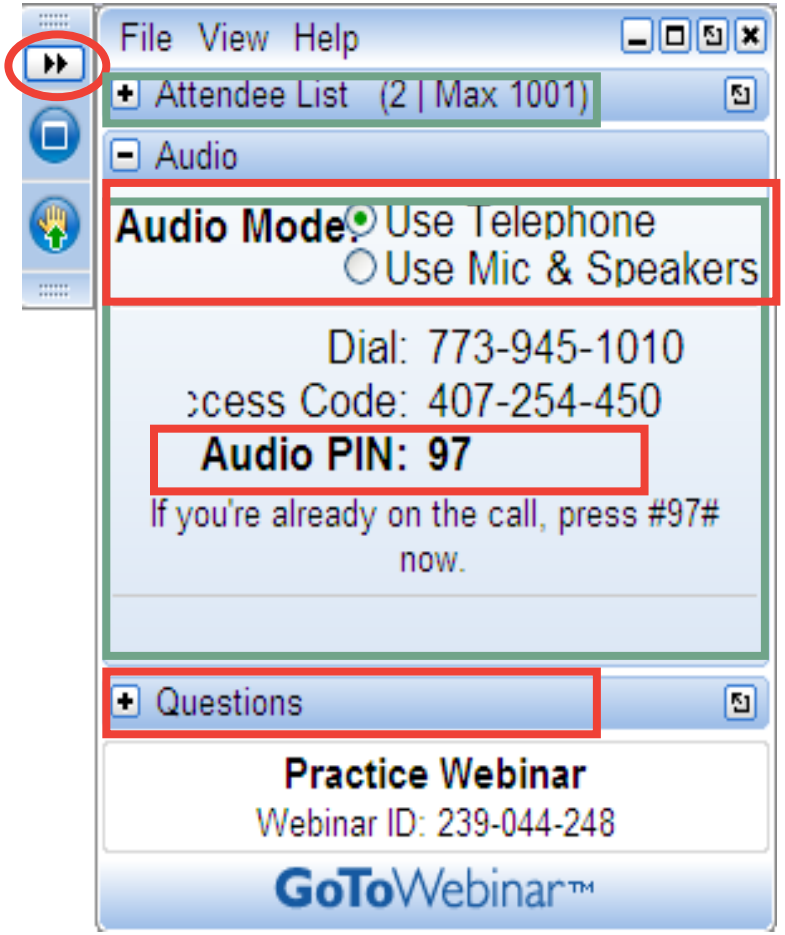
USING GOTOWEBINAR

Open and close your **control panel**



Choose **audio mode**

Enter your **audio pin**

Type **questions** in the "questions" box

Questions will be taken at the end of the presentation.

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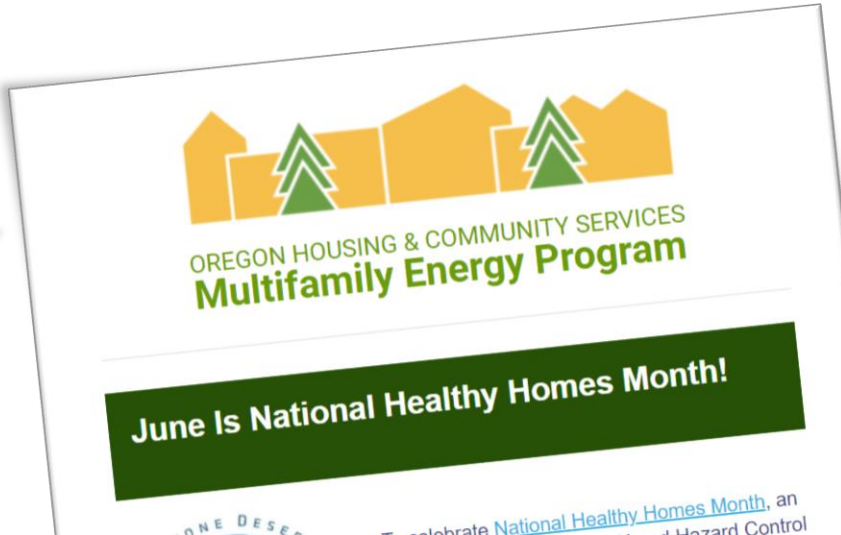
REGISTER FOR UPCOMING TRAININGS

- **Thursday, Sept 13, 2018, 12pm:**
  Effective Ventilation Strategies **|** **REGISTER**

- **Thursday, Sept 27, 2018, 12pm:**
  Planning for Energy Efficiency Upgrades **| REGISTER**

SIGN UP
for the monthly newsletter to stay updated on future trainings and useful info!



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AGENDA

- **Energy Modeling:**
  What? Why? Who? When?
- **OR-MEP Modeling Requirements**
- **Workflow Efficiency:**
  Tips & Tricks
- **Model QA:**
  Troubleshooting & Interpreting Model Results

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ENERGY MODELING BASICS

WHAT?	Computer simulation models of building systems to estimate energy savings and explore energy efficient design options.
WHY?	A design tool to optimize energy savings and cost effectiveness. Used for code compliance, certification programs, tax credits, and incentive programs.
WHO?	Architects, HVAC engineers, energy consultants, etc.
WHEN?	Start energy modeling as early as possible! Refine as the design progresses *(…integrated design).*

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MODELING PROCESS

Step 1
- **Create baseline model** *(EB: existing conditions; NC: code)*

Step 2
- **Develop list of proposed energy efficiency measures**

Step 3
- **Create proposed design model**

Step 4
- **Calculate and analyze energy savings**

Step 5
- **Repeat Steps 2-4 until desired energy performance is achieved; adjust baseline model if needed**

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OR-MEP & ENERGY MODELING

- Program Pathways
- Modeling Requirements
- Technical Review Process

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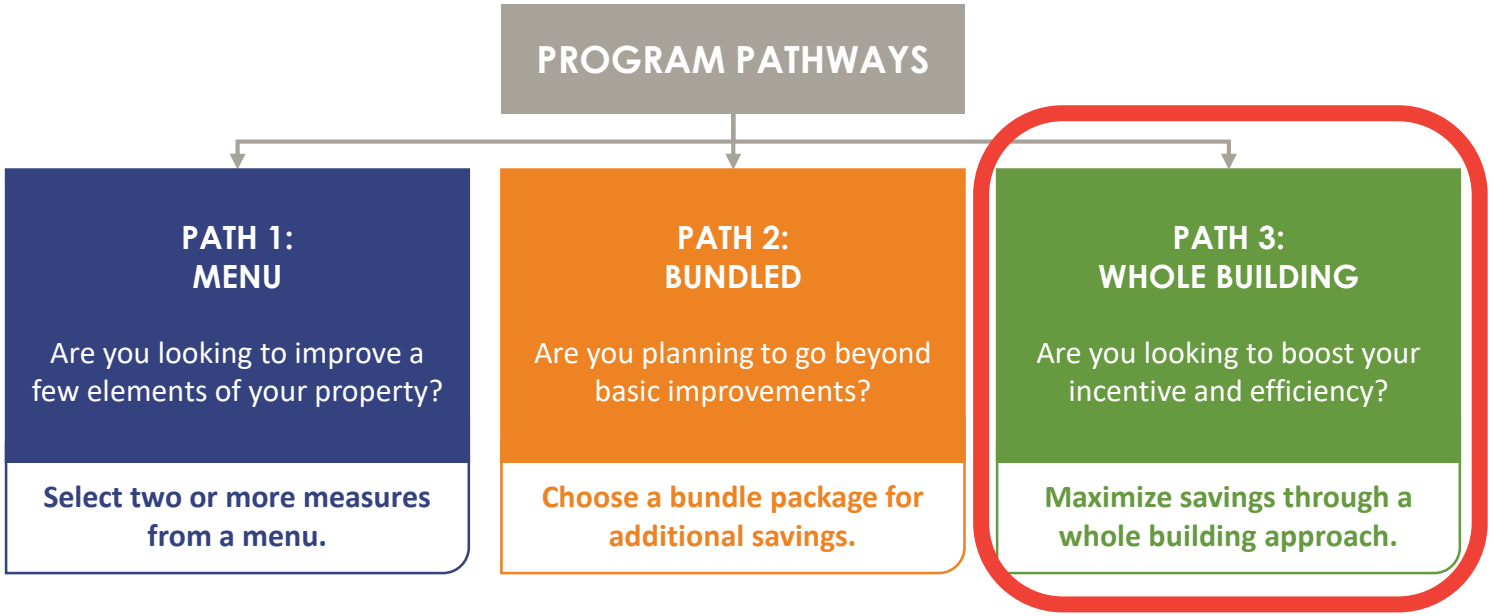
PROGRAM PATHWAYS

- Existing multifamily and new multifamily both have three paths, suited for varying scopes of work
- Incentives escalate to reward more comprehensive design strategies



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WHOLE BUILDING PATH

EXISTING BUILDING

- Three incentive tiers based on percent savings over *existing conditions*
- Requires whole building audit and energy modeling

NEW CONSTRUCTION

- Three incentive tiers based on percent savings over *code baseline*
- Requires energy modeling

Tier	Savings Threshold	Incentive
Tier 1	≥ 20% kWh savings compared to *existing conditions (EB)* or *code baseline (NC)*	$0.80 / kWh saved
Tier 2	≥ 25% kWh savings compared to *existing conditions (EB)* or *code baseline (NC)*	$0.90 / kWh saved
Tier 3	≥ 30% kWh savings compared to *existing conditions (EB)* or *code baseline (NC)*	$1.00 / kWh saved

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MODELING REQUIREMENTS

EXISTING BUILDING

- Requires whole building audit and energy modeling
- Baseline: existing conditions

NEW CONSTRUCTION

- Requires energy modeling
- Baseline: code
  - *Low-Rise (3 stories or less)* follow Oregon Residential Specialty Code
  - *Mid- and High-Rise (4+ stories)* follow Oregon Energy Efficiency Specialty Code

Approved Energy Modeling Tools:

DOE-2	eQUEST	EnergyPro	HAP
REM/Rate	REM/Design	TRACE	TREAT

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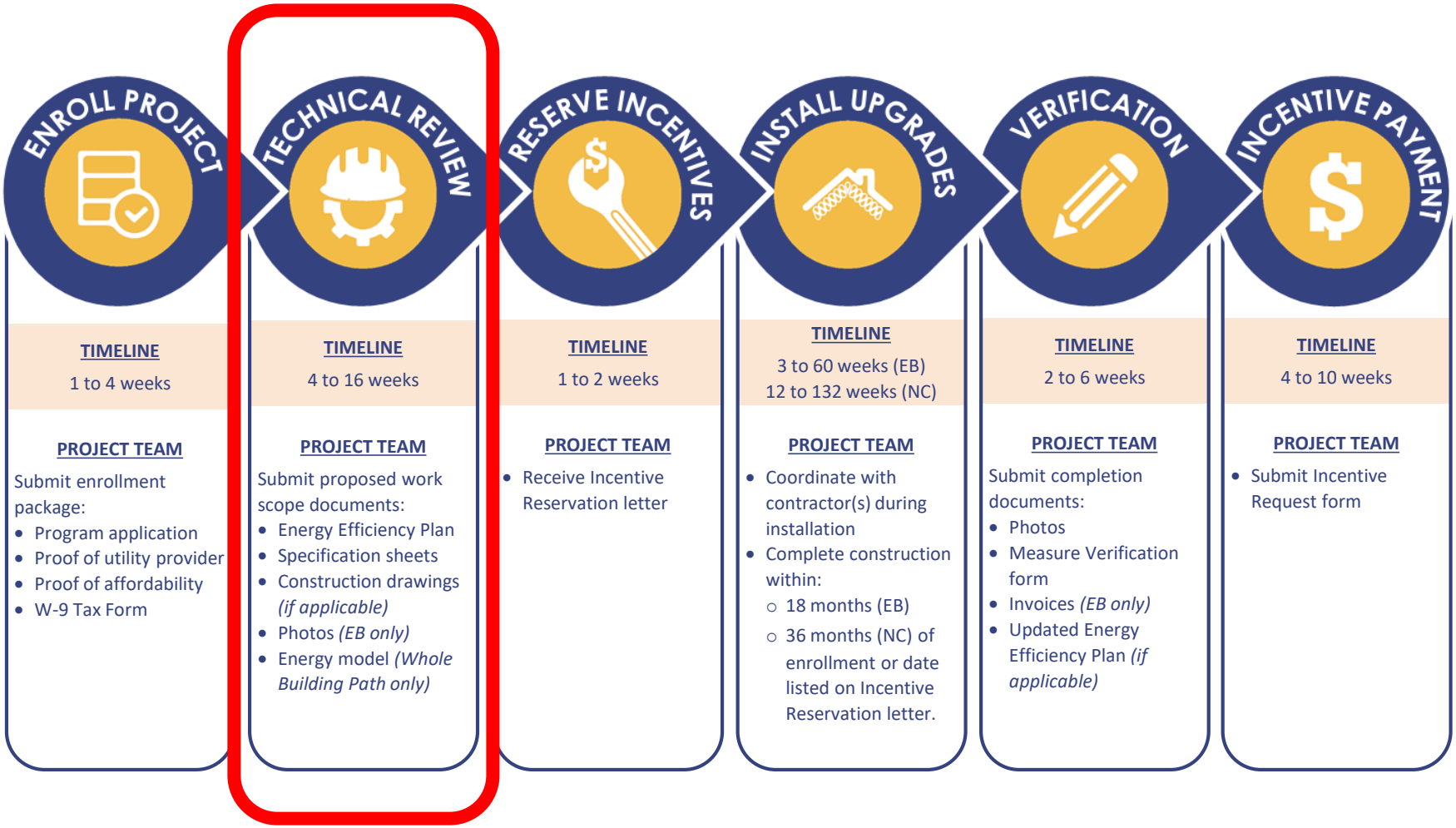
TECHNICAL REVIEW PROCESS



TIMELINE
1 to 4 weeks

PROJECT TEAM

Submit enrollment package:

- Program application
- Proof of utility provider
- Proof of affordability
- W-9 Tax Form

TIMELINE
4 to 16 weeks

PROJECT TEAM

Submit proposed work scope documents:

- Energy Efficiency Plan
- Specification sheets
- Construction drawings *(if applicable)*
- Photos *(EB only)*
- Energy model *(Whole Building Path only)*

TIMELINE
1 to 2 weeks

PROJECT TEAM

- Receive Incentive Reservation letter

TIMELINE
3 to 60 weeks (EB)
12 to 132 weeks (NC)

PROJECT TEAM

- Coordinate with contractor(s) during installation
- Complete construction within:
  - 18 months (EB)
  - 36 months (NC) of enrollment or date listed on Incentive Reservation letter.

TIMELINE
2 to 6 weeks

PROJECT TEAM

Submit completion documents:

- Photos
- Measure Verification form
- Invoices *(EB only)*
- Updated Energy Efficiency Plan *(if applicable)*

TIMELINE
4 to 10 weeks

PROJECT TEAM

- Submit Incentive Request form

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PROGRAM DOCUMENTS
ENERGY EFFICIENCY PLAN

WHOLE BUILDING PATH - DETAILED MEASURES TABLE

Instructions

1. Fill out all light purple shaded cells.
2. Enter baseline energy consumption details in cells G8 and H8. This should match the baseline model. The percent electric savings will be calculated based on the baseline annual kWh consumption.
3. In rows 11-21, provide measure level cost and savings details for all measure in the proposed work scope. Savings information should come from model and/or external calculations.
4. Once, all required information is provided eligible program incentives will be summarized starting in row 26.

PROJECT TYPE
New Construction

BASELINE ENERGY CONSUMPTION		
Baseline Type	Annual kWh	Annual Therms
Code Baseline	491,905	6,576

UTILITY RATES	
$ / kWh	$ / therm
$0.11	$1.17

	Measure Name	Estimated Install Cost	Owner or Tenant Savings?	Measure Type	Measure Sub-Type	Estimated Annual Energy Savings		Include in Scope?	% Electric Savings	Annual Cost Savings	Measure Life (EUL)	Savings to Investment Ratio (SIR)	Life Cycle Savings	GHG Savings	Site Energy Savings %
PROPOSED ENERGY SAVINGS MEASURES						kWh	Therm			$	Years		$	MTCO2	
1	Wall Insulation (R-30)	$170,072	Tenant	Envelope	Wall Insulation	31,114	2	Yes	6.3%	$3,406	45	0.5	$83,516	4.84	4.6%
2	Windows (U-0.23; SHGC-0.29)	$20,458	Tenant	Envelope	Windows	22,974	0	Yes	4.7%	$2,513	45	3.0	$61,624	3.57	3.4%
3	Door (R-5)	$3,360	Tenant	Envelope	Other	4,246	0	Yes	0.9%	$465	45	3.4	$11,389	0.66	0.6%
4	Attic/Roof Insulation (R-60)	$3,478	Tenant	Envelope	Attic Insulation	8,946	0	Yes	1.8%	$979	45	6.9	$23,996	1.39	1.3%
5	Reduced Infiltration (3.5 ACH50)	$27,722	Tenant	Envelope	Other	34,496	-2	Yes	7.0%	$3,772	45	3.3	$92,473	5.35	5.0%
6	VRF Heat Pumps	$74,531	Tenant	HVAC	Ductless Heat Pump (mini-sp	22,974	0	Yes	4.7%	$2,513	15	0.4	$30,004	3.57	3.4%
7	Energy Recovery Ventilation	$105,625	Tenant	HVAC	Other	12,488	0	Yes	2.5%	$1,366	15	0.2	$16,309	1.94	1.8%
8	ENERGY STAR Refrigerators	$10,800	Tenant	Appliance	Refrigerator	5,594	0	Yes	1.1%	$612	15	0.7	$7,306	0.87	0.8%
9	ENERGY STAR Dishwashers	$12,000	Tenant	Appliance	Dishwasher	6,912	148	Yes	1.4%	$929	11	0.7	$8,595	1.86	1.6%
10	LED Interior Lighting	$34,364	Tenant	Lighting	In-Unit Lighting (LED)	58,867	0	Yes	12.0%	$6,440	20	2.8	$95,812	9.14	8.6%
11									0.0%	$0	0	0.0	$0	0.00	0.0%
12									0.0%	$0	0	0.0	$0	0.00	0.0%
13									0.0%	$0	0	0.0	$0	0.00	0.0%
14									0.0%	$0	0	0.0	$0	0.00	0.0%
15									0.0%	$0	0	0.0	$0	0.00	0.0%
	TOTAL	$462,410				208,611	148		42.4%	$22,995		0.9	$431,025	33.18	31.1%

OR-MEP INCENTIVE SUMMARY	
Total kWh Savings	208,611
Percent kWh Savings	42.4%
Eligible Incentive Tier	Tier 3
Total Incentive	$200,000

LEVERAGED FUNDING SUMMARY		
Total Project Cost		$462,410
OR-MEP Incentive		$200,000
Leveraged Funding #1	Energy Trust of Oregon	$0
Leveraged Funding #2	<NAME OF FUNDING SOURCE>	$0
Leveraged Funding #3	<NAME OF FUNDING SOURCE>	$0
Leveraged Funding #4	<NAME OF FUNDING SOURCE>	$0
Remaining Non-Leveraged Project Costs		$262,410

SAVINGS AND PAYBACK SUMMARY	
Simple Payback to Owner (Pre-Incentives)	0.0
Simple Payback to Owner (After Incentives)	0.0
Percent Reduction in Project Costs	43%
Owner Annual Savings	$0
Tenant Annual Savings	$22,995

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GOALS OF TECHNICAL REVIEW

- Determine if project is eligible for funding
- Verify estimated modeled savings
- Identify significant issues
- Limit number of revisions
- Standardize the process

Support energy consultants to be model experts.

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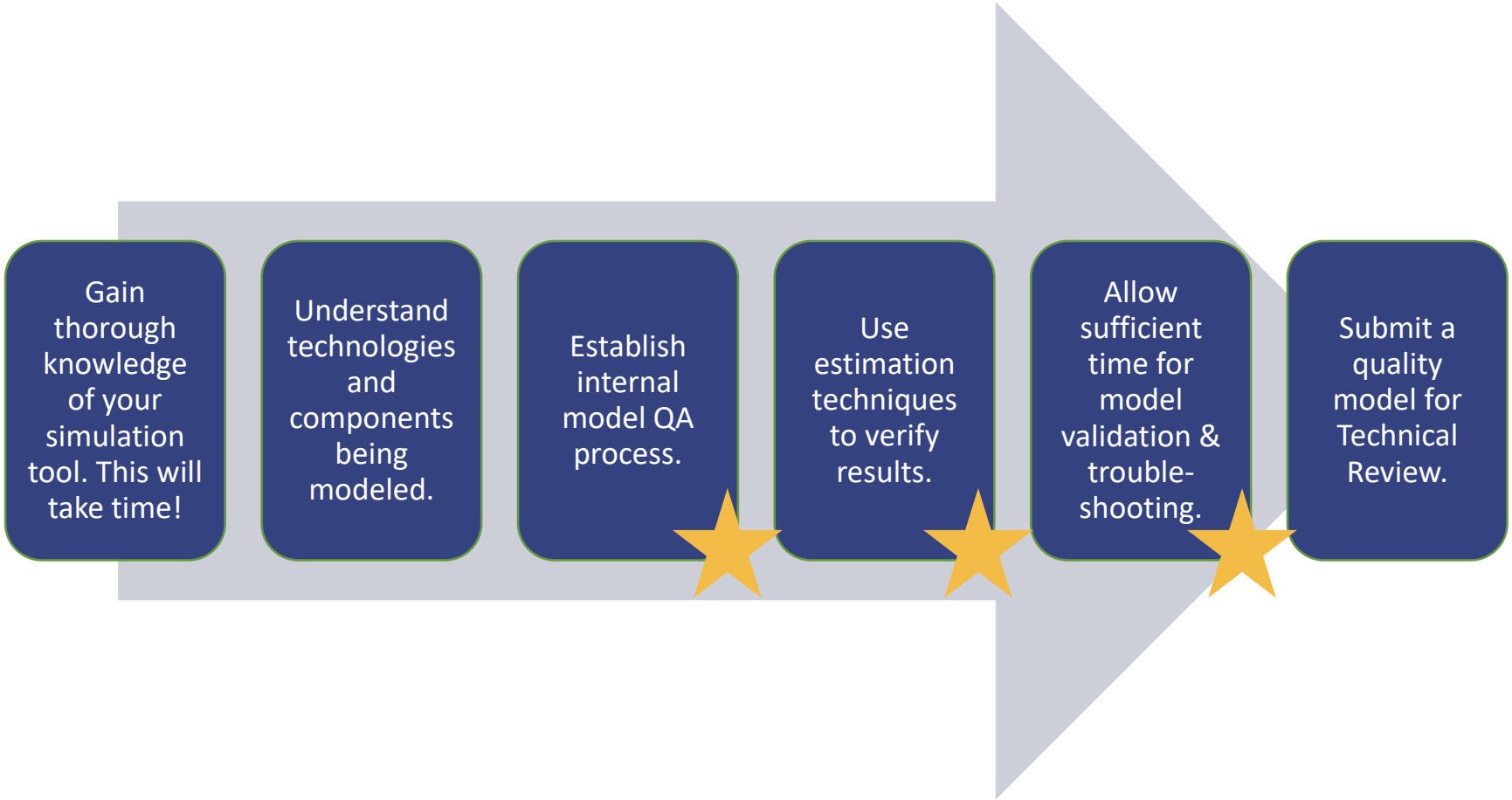
HOW TO BUILD QUALITY MODELS?



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MODELING TIPS & TRICKS

- **Workflow Efficiency**
- **Model QA**

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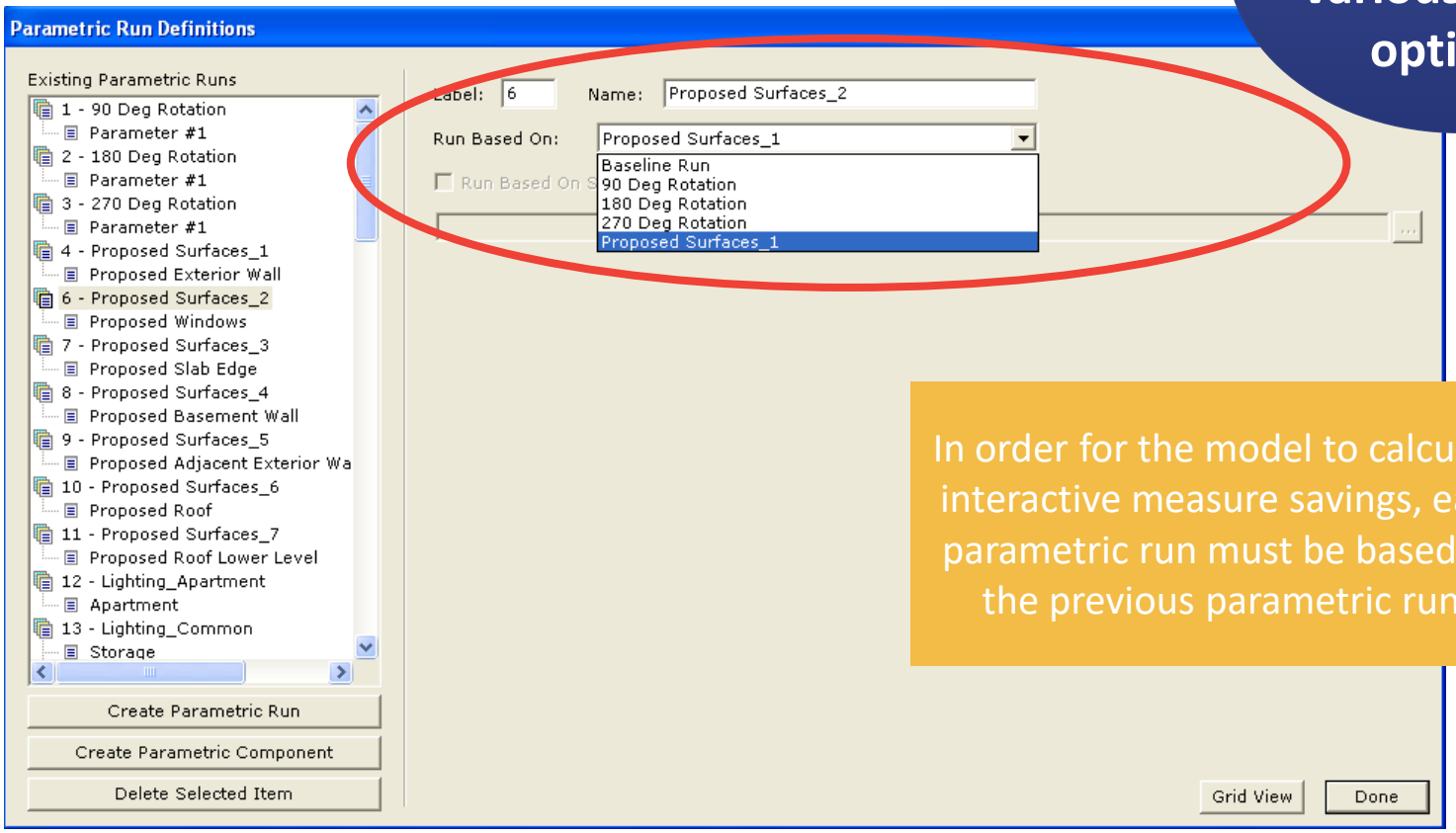
WORKFLOW EFFICIENCY
Interactive Measure Runs

Detailed Mode – Parametric Runs (eQuest):

Save time modeling various design options.



In order for the model to calculate interactive measure savings, each parametric run must be based on the previous parametric run.

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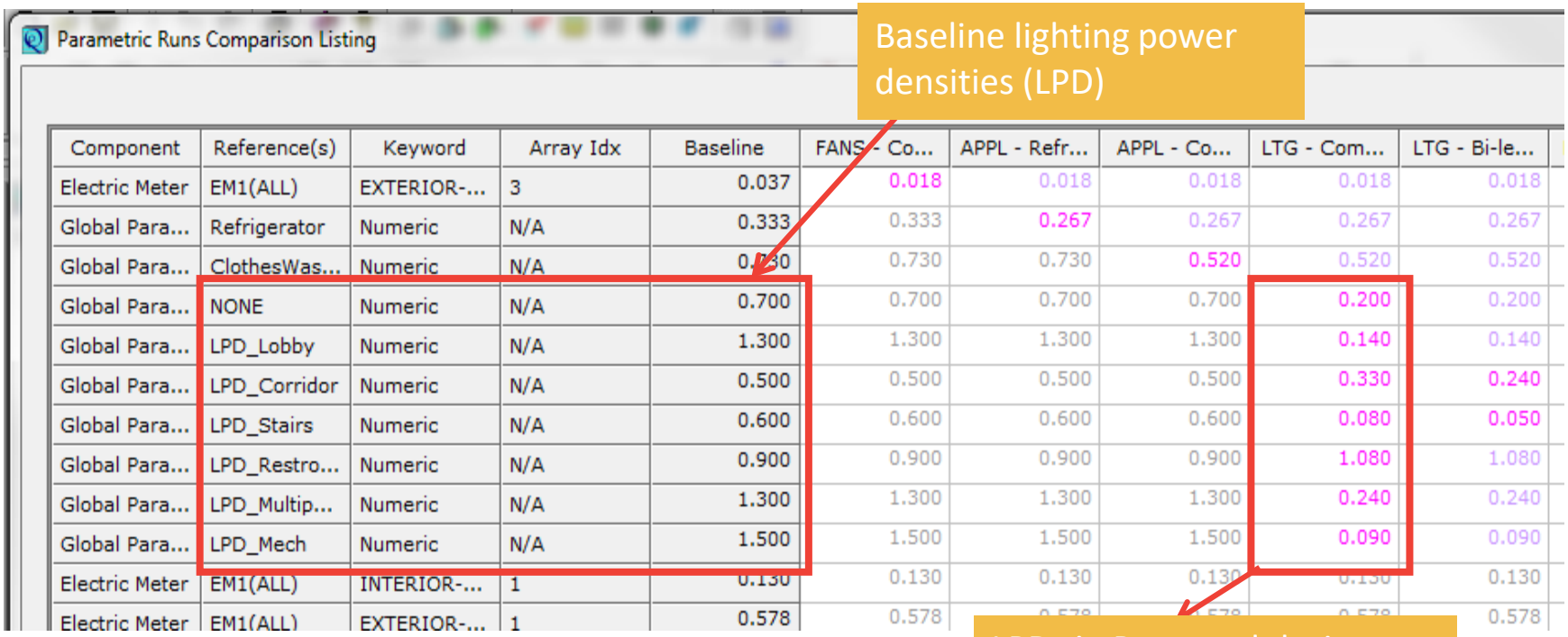
WORKFLOW EFFICIENCY
Interactive Measure Runs

Verify Measure Model Inputs:

Using the grid view of eQuest Parametric run tool as shown, verify that only the inputs identified in the submittal vary between the Baseline and Proposed model.



Component	Reference(s)	Keyword	Array Idx	Baseline	FANS - Co...	APPL - Refr...	APPL - Co...	LTG - Com...	LTG - Bi-le...
Electric Meter	EM1(ALL)	EXTERIOR-...	3	0.037	0.018	0.018	0.018	0.018	0.018
Global Para...	Refrigerator	Numeric	N/A	0.333	0.333	0.267	0.267	0.267	0.267
Global Para...	ClothesWas...	Numeric	N/A	0.730	0.730	0.730	0.520	0.520	0.520
Global Para...	NONE	Numeric	N/A	0.700	0.700	0.700	0.700	0.200	0.200
Global Para...	LPD_Lobby	Numeric	N/A	1.300	1.300	1.300	1.300	0.140	0.140
Global Para...	LPD_Corridor	Numeric	N/A	0.500	0.500	0.500	0.500	0.330	0.240
Global Para...	LPD_Stairs	Numeric	N/A	0.600	0.600	0.600	0.600	0.080	0.050
Global Para...	LPD_Restro...	Numeric	N/A	0.900	0.900	0.900	0.900	1.080	1.080
Global Para...	LPD_Multip...	Numeric	N/A	1.300	1.300	1.300	1.300	0.240	0.240
Global Para...	LPD_Mech	Numeric	N/A	1.500	1.500	1.500	1.500	0.090	0.090
Electric Meter	EM1(ALL)	INTERIOR-...	1	0.130	0.130	0.130	0.130	0.130	0.130
Electric Meter	EM1(ALL)	EXTERIOR-...	1	0.578	0.578	0.578	0.578	0.578	0.578

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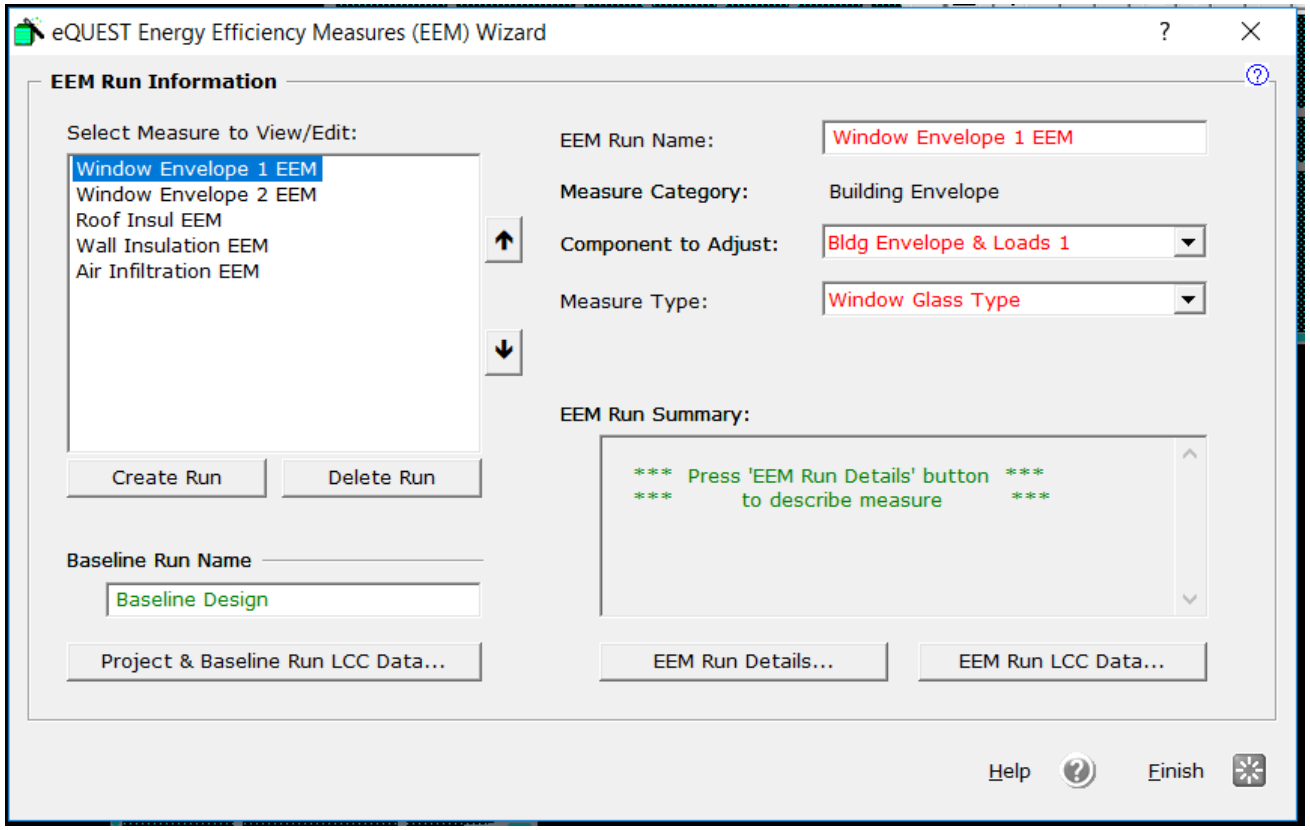
WORKFLOW EFFICIENCY
Interactive Measure Runs

Wizard Mode – EEM Run Wizard (eQuest):



WORKFLOW EFFICIENCY
Standardize Inputs

Global Parameters (eQuest):

Global Parameters

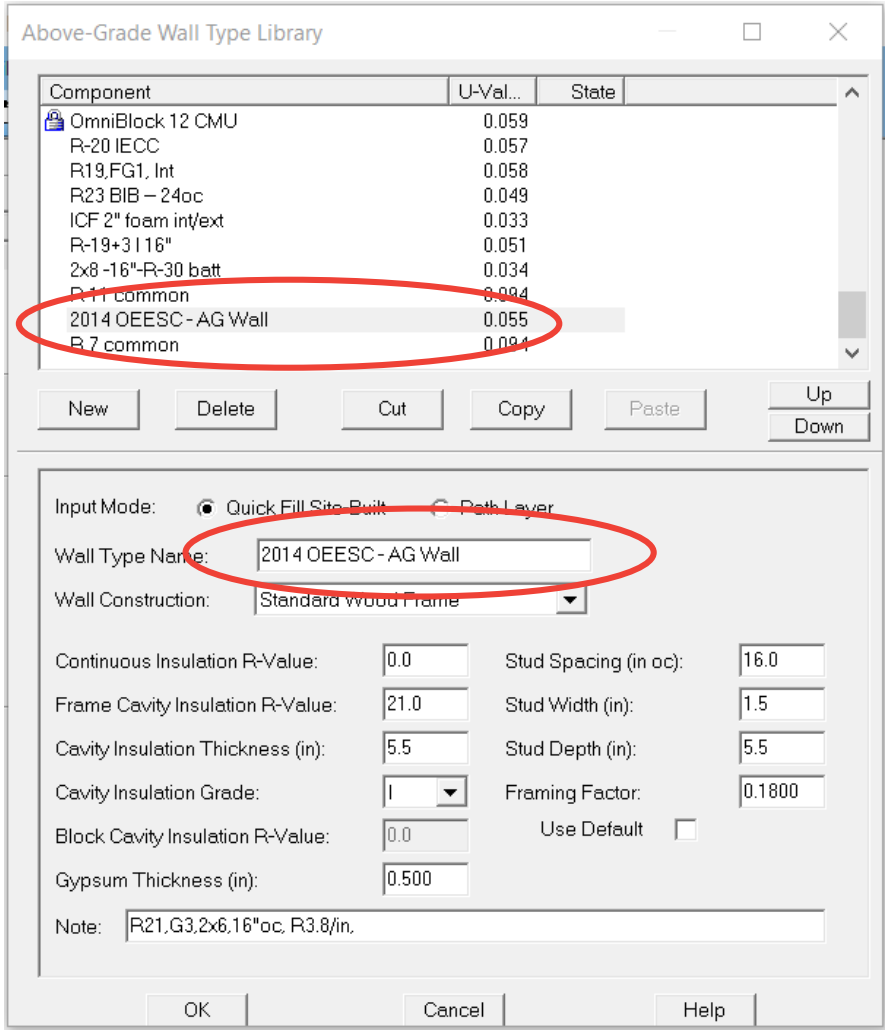
	Parameter Name	Parameter Type	Parameter Value
1	LPD_Unit	Numeric	0.7000
2	LPD_Corridor	Numeric	0.5000
3	LPD_Stairs	Numeric	0.6000
4	LPD_Storage	Numeric	0.8000
5	LPD_Multipurpose	Numeric	1.3000
6	LPD_Mech	Numeric	1.5000
7	LPD_Lobby	Numeric	1.3000
8	LPD_Restroom	Numeric	0.9000
9	LPD_Office	Numeric	1.1000
10	LPD_Garage	Numeric	0.2000
11	LPD_Retail	Numeric	1.7000
12	LPD_Gym	Numeric	0.9000
13	LPD_Lounge	Numeric	1.2000
14	LPD_Lockers	Numeric	0.6000
15	LPD_WKSP	Numeric	1.9000

Done

WORKFLOW EFFICIENCY
Standardize Inputs

Libraries (REM/Rate):

Create library of components (wall, roof, windows, heating systems, etc.) for baseline code requirements and typical proposed measures.



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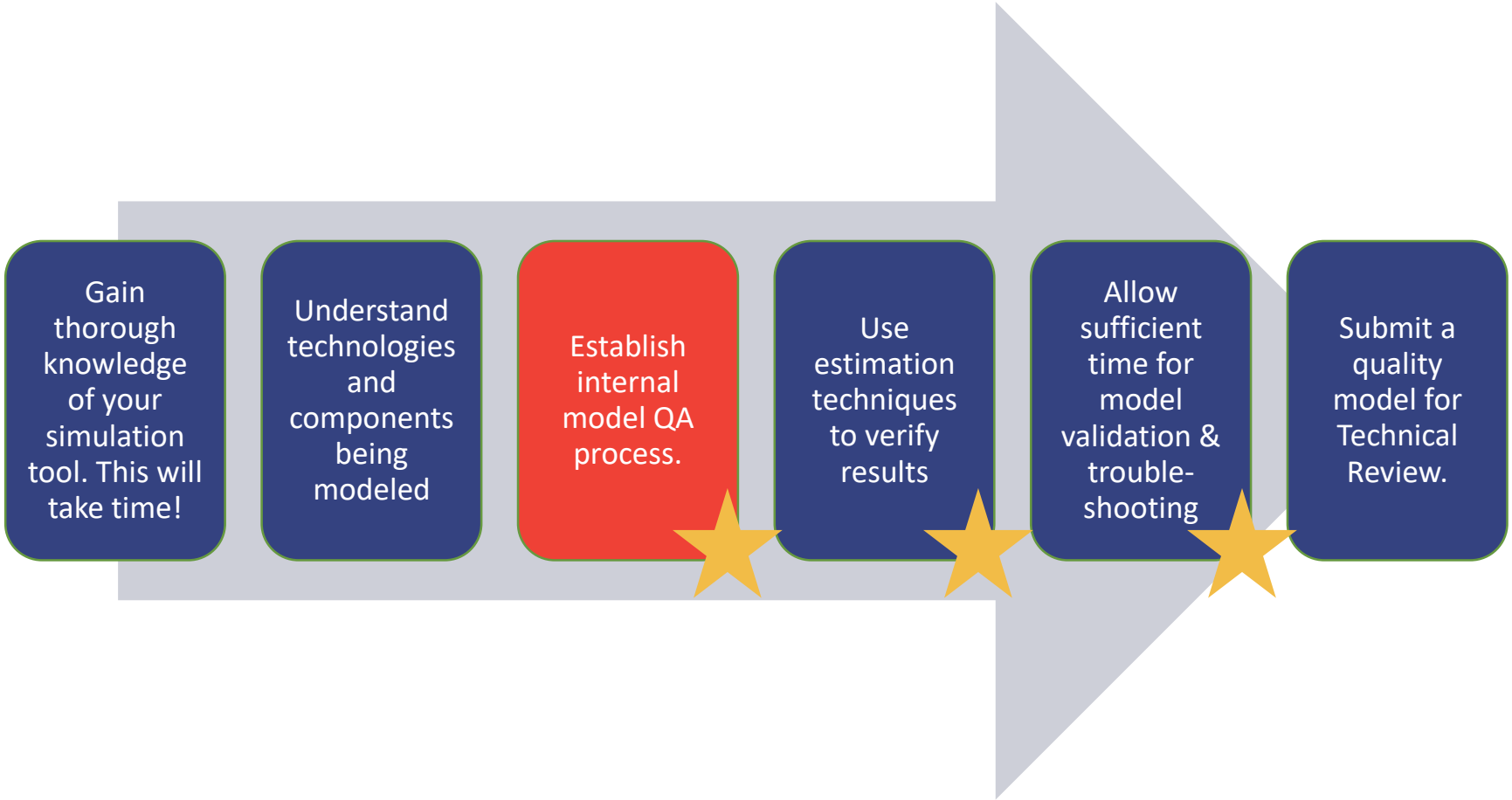
MODEL QA



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MODEL QA
Model Output Reports

Evaluate General Quality of Simulation:

Number of hours outside of throttling range

REPORT- BEPS Building Energy Performance — WEATHER FILE- SYRACUSE, NY

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM1 ELECTRICITY													
MBTU	193.2	0.0	269.8	0.0	31.4	0.0	25.2	76.0	0.0	0.0	0.0	10.9	606.5
FM1 NATURAL-GAS													
MBTU	0.0	0.0	36489.0	1294.5	0.0	0.0	0.0	0.0	0.0	0.0	212.5	0.0	37996.1
MBTU	193.2	0.0	36758.8	1294.5	31.4	0.0	25.2	76.0	0.0	0.0	212.5	10.9	38602.6

TOTAL SITE ENERGY 38602.58 MBTU 1660.1 KBTU/SQFT-YR GROSS-AREA 1660.1 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 39815.63 MBTU 1712.2 KBTU/SQFT-YR GROSS-AREA 1712.2 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 7.77
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 1
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 423

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

Per ASHRAE 90.1 – 2010 Appendix G, this percent must not exceed 3.4, or 300 hours per year.

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MODEL QA
Model Output Reports

Evaluate General Quality of Simulation:

Correct/prevent hours outside of throttling range

REPORT- SS-R Zone Performance Summary for EL1 Sys1 (PMZS) (B.C4) WEATHER FILE- New York CityNY TMY2

ZONE	ZONE OF MAXIMUM HTG DMND (HOURS)	ZONE OF MAXIMUM CLG DMND (HOURS)	ZONE UNDER HEATED (HOURS)	ZONE UNDER COOLED (HOURS)	Number of hours within each PART LOAD range 00 10	10 20	20 30	30 40	40 50	50 60	60 70	70 80	80 90	90 100	100 +	TOTAL RUN HOURS
EL1 Core Zn (B.C4)	0	0	181	0	0	0	0	0	0	0	0	0	0	0	4631	4631
TOTAL	0	0	181	0												

Use the two columns circled to identify which zones in your model are under-heated and/or under-cooled.

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MODEL QA
Model Output Reports

Evaluate General Quality of Simulation:

Use the "SS-F Zone Demand Summary" report to check during which time of year the unmet loads occur.

REPORT- SS-F Zone Demand Summary for AptJ_zn7 WEATHER FILE- New York CityNY TMY2

	-DEMANDS-		-BASEBOARDS-		-TEMPERATURES-		-LOADS NOT MET-	
MONTH	HEAT EXTRACTION ENERGY (MBTU)	HEAT ADDITION ENERGY (MBTU)	BASEBOARD ENERGY (MBTU)	MAXIMUM BASEBOARD LOAD (KBTU/HR)	MAXIMUM ZONE TEMP (F)	MINIMUM ZONE TEMP (F)	HOURS UNDER HEATED	HOURS UNDER COOLED
JAN	0.00000	-4.119	0.00000	0.000	74.4	69.8	1	0
FEB	0.00000	-2.964	0.00000	0.000	76.8	69.9	0	0
MAR	0.04637	-2.180	0.00000	0.000	79.8	70.0	0	0
APR	0.09402	-0.933	0.00000	0.000	79.9	70.0	0	0
MAY	0.60151	-0.088	0.00000	0.000	80.1	70.1	0	0
JUN	1.47067	0.000	0.00000	0.000	80.1	72.6	0	0
JUL	2.22731	0.000	0.00000	0.000	80.2	75.9	0	4
AUG	1.78297	0.000	0.00000	0.000	80.1	74.4	0	0
SEP	1.14602	-0.007	0.00000	0.000	80.1	70.2	0	0
OCT	0.17378	-0.350	0.00000	0.000	80.0	70.1	0	0
NOV	0.00000	-1.621	0.00000	0.000	77.0	70.0	0	0
DEC	0.00074	-3.040	0.00000	0.000	78.3	69.9	0	0

MODEL QA
Model Output Reports

Evaluate General Quality of Simulation:

Check the square footage

REPORT- LS-C BuiLding Peak Load Components WEATHER FILE- Buffalo

*** BUILDING ***

FLOOR AREA	86735	SQFT	8058	M2
VOLUME	784597	CUFT	22220	M3

	COOLING LOAD		HEATING LOAD	
TIME	JUL 2 7PM		FEB 2 3AM	
DRY-BULB TEMP	88 F	31 C	-2 F	-19 C
WET-BULB TEMP	71 F	22 C	-3 F	-19 C
TOT HORIZONTAL SOLAR RAD	113 BTU/H.SQFT	356 W/M2	0 BTU/H.SQFT	0 W/M2
WINDSPEED AT SPACE	9.5 KTS	4.9 M/S	9.5 KTS	4.9 M/S
CLOUD AMOUNT 0(CLEAR)-10	0		9	

Is the square footage reported in EEP within range of modeled square footage? (~10%)

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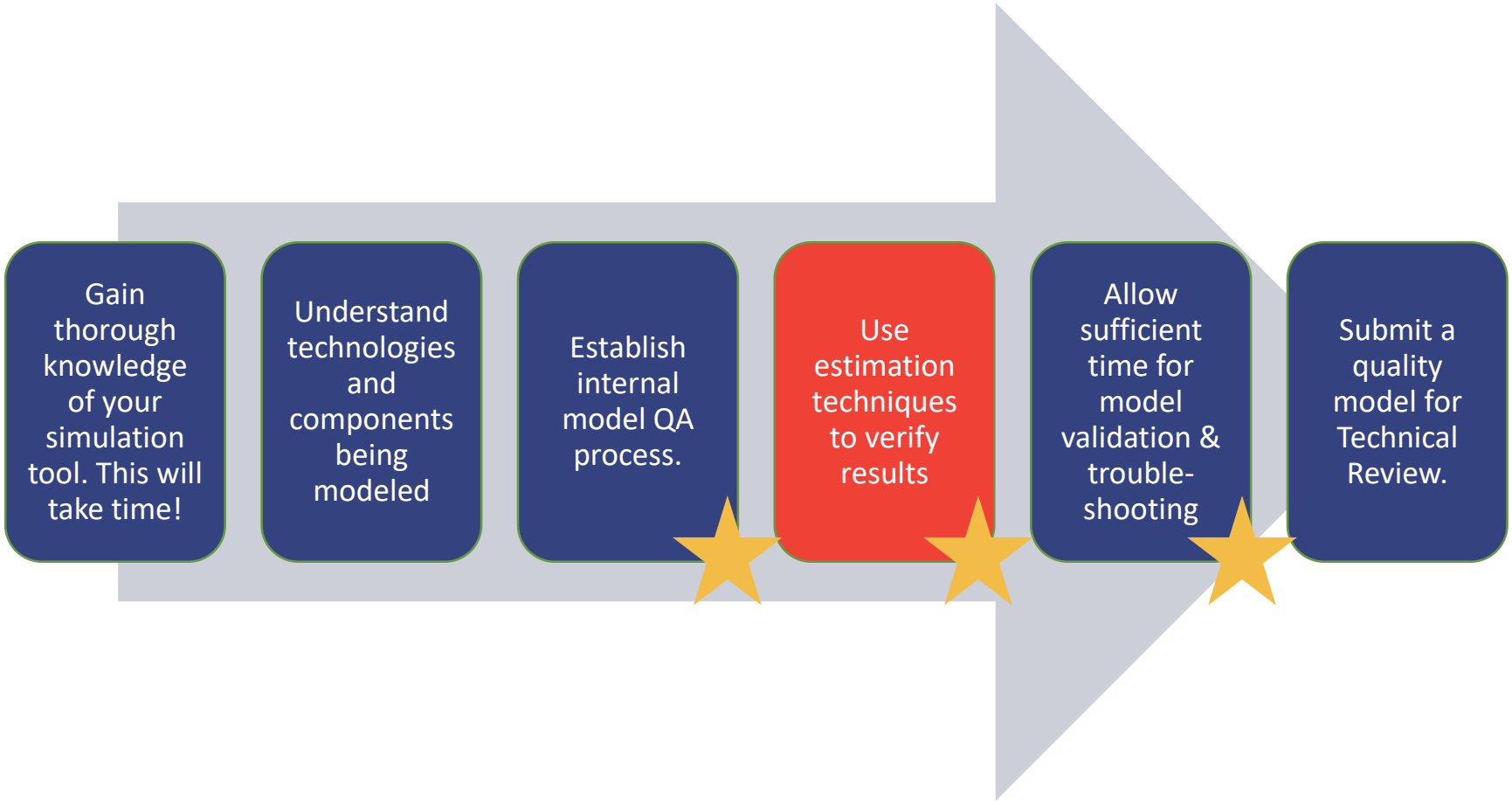
MODEL QA
Verify Measure Savings



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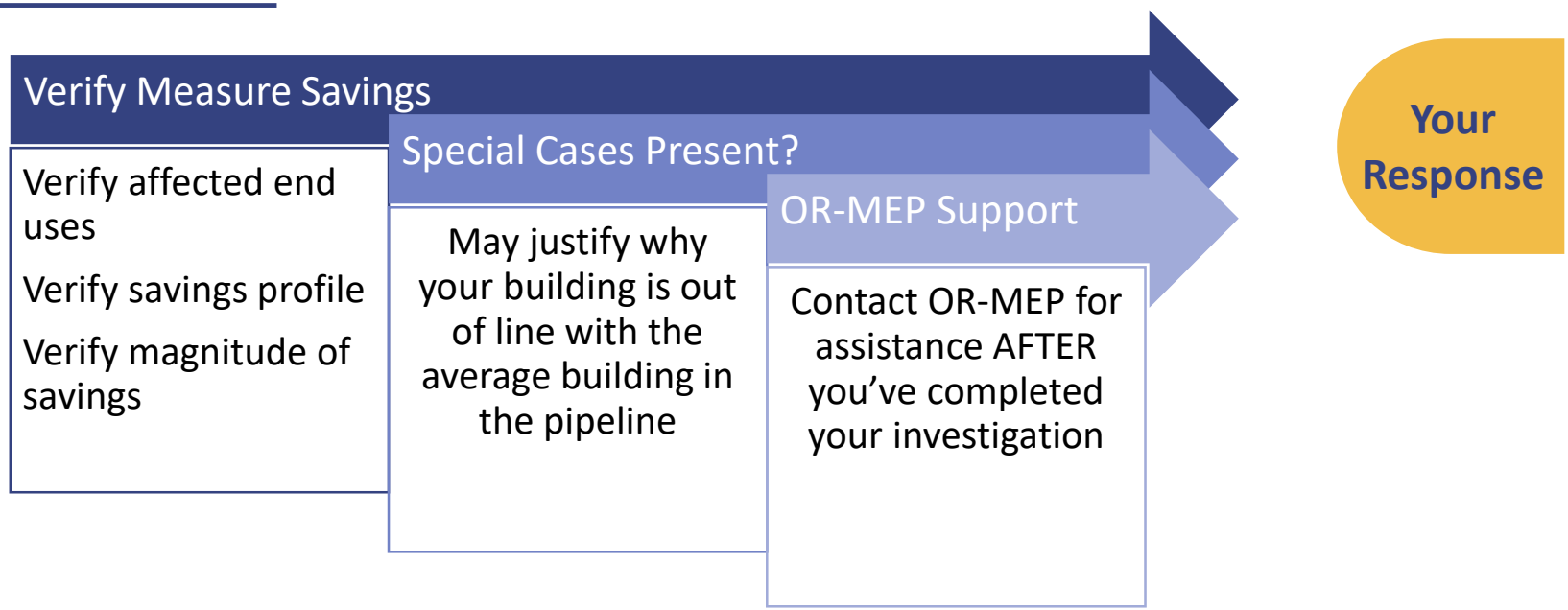
MODEL QA
Verify Measure Savings

[OR-MEP] The proposed in-unit lighting savings is higher than what we would expect for a multifamily building. Please investigate possible causes of this discrepancy.

How to Proceed:



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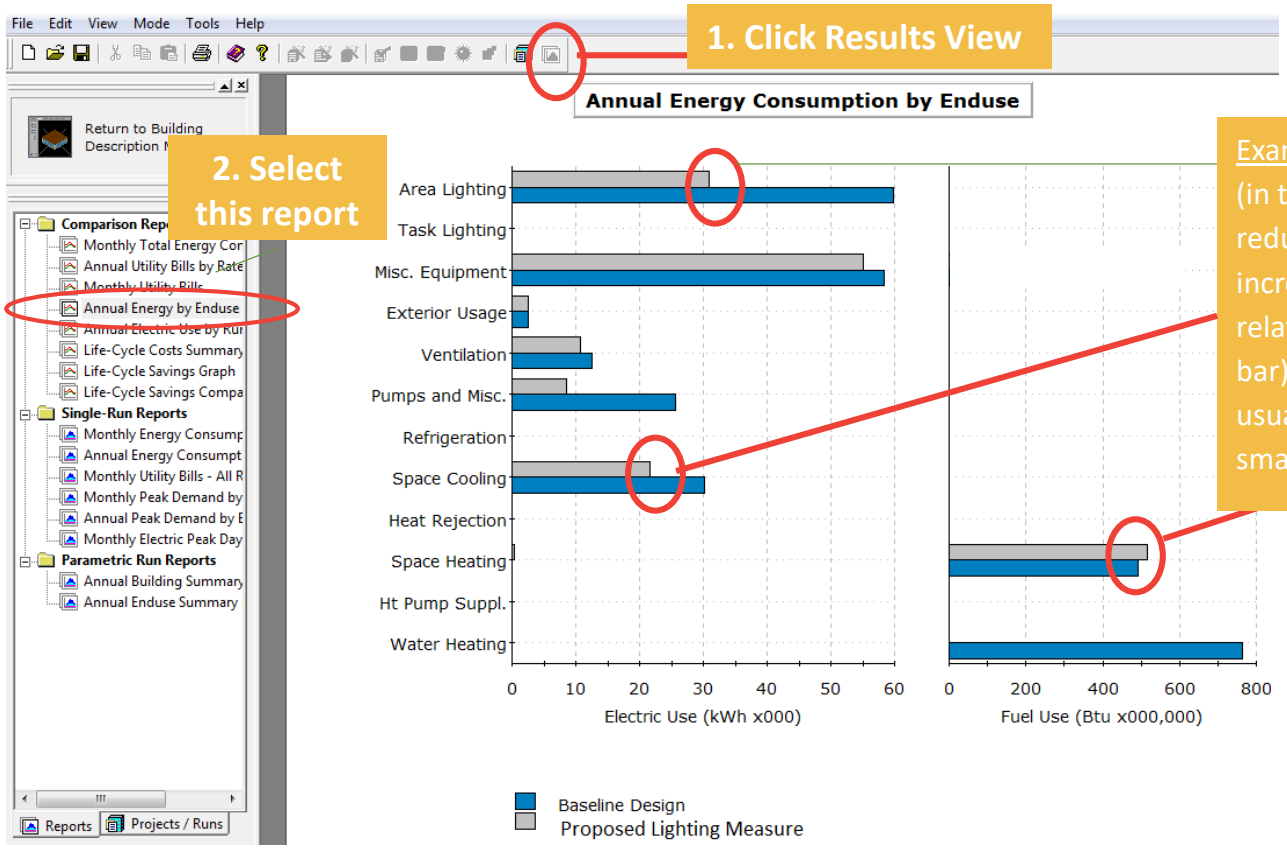
MODEL QA
Verify Measure Savings

Review Affected End Use(s):

Evaluate affected end uses and savings (annual energy by end use report)



Example: Common Area Lighting (in the screenshot gray bar) reduces lighting and cooling and increases heating consumption relative to the Baseline run (blue bar). Fan and power pump is usually also affected, but to a smaller degree.

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MODEL QA
Verify Measure Savings

Verify Savings Profile*:

Measure Type	Heating kWh Savings	Cooling kWh Savings	Non-Heating / Cooling kWh Savings
Insulation – Walls	Positive	Positive	-
Insulation – Roof/Attic	Positive	Positive	-
Windows	Positive	Positive	-
Refrigerators - ENERGY STAR	Negative	Positive	Positive
Dishwashers – ENERGY STAR	Negative	Positive	Positive
Washing Machines – ENERGY STAR	Negative	Positive	Positive
Lighting – LED	Negative	Positive	Positive
PTHP / DHP	Positive	Positive	-
Ventilation Fans	-	-	Positive

**For electric-heated apartment building*

Does installing higher efficiency lighting:

Save heating kWh? NO!
Save cooling kWh? YES!
Save non-heating/cooling kWh? YES!

MODEL QA
Verify Measure Savings

Develop Simple Estimation Techniques:

You have an in-unit lighting measure.
Calculate the total non-heating/cooling kWh savings from the watt reduction between the baseline and proposed multiplied by the SF and hours/day schedule.

Baseline LPD: 0.7 W/SF

Proposed LPD: 0.65 W/SF

Apartment Runtimes: 2.34 Hrs/Day

Total Sq Ft of Apartments = 7,372

(0.7 w/sf – 0.65 w/sf) * 7,372 Sqft * 2.34 hrs/day * 365 days/yr ÷ 1000W/kW =
314.8 kWh/yr [Non-Heating/Cooling] savings

Oregon Housing and Community Services

TRC
Results you can rely on

MODEL QA
Verify Measure Savings

Non-heating/cooling kWh will decrease by 314.8 kWh/yr.

Cooling kWh will decrease due to lower internal heat gain. Typical Cooling kWh savings is 15-30% of Non-Cooling kWh savings.

Heating kWH will increase because the lower internal heat gain has to be compensated for by the space heating system.

Oregon Housing and Community Services

TRC Results you can rely on

MODEL QA
Verify Measure Savings

Verify Magnitude of Savings:

Looking at the distribution of electric % savings among measures is another way to review model results.

PROJECT TYPE
New Construction

BASELINE ENERGY CONSUMPTION		
Baseline Type	Annual kWh	Annual Therms
Code Baseline	491,905	6,576

	Measure Name	Estimated Install Cost	Owner or Tenant Savings?	Measure Type	Measure Sub-Type	Estimated Annual Energy Savings		Include in Scope?	% Electric Savings	Annual Cost Savings
PROPOSED ENERGY SAVINGS MEASURES						kWh	Therm			$
1	Wall Insulation (R-30)	$170,072	Tenant	Envelope	Wall Insulation	31,114	2	Yes	6.3%	$3,406
2	Windows (U-0.23; SHGC-0.29)	$20,458	Tenant	Envelope	Windows	22,974	0	Yes	4.7%	$2,513
3	Door (R-5)	$3,360	Tenant	Envelope	Other	4,246	0	Yes	0.9%	$465
4	Attic/Roof Insulation (R-60)	$3,478	Tenant	Envelope	Attic Insulation	8,946	0	Yes	1.8%	$979
5	Reduced Infiltration (3.5 ACH50)	$27,722	Tenant	Envelope	Other	34,496	-2	Yes	7.0%	$3,772
6	VRF Heat Pumps	$74,531	Tenant	HVAC	Ductless Heat Pump (mini-split)	22,974	0	Yes	4.7%	$2,513
7	Energy Recovery Ventilation	$105,625	Tenant	HVAC	Other	12,488	0	Yes	2.5%	$1,366
8	ENERGY STAR Refrigerators	$10,800	Tenant	Appliance	Refrigerator	5,594	0	Yes	1.1%	$612
9	ENERGY STAR Dishwashers	$12,000	Tenant	Appliance	Dishwasher	6,912	148	Yes	1.4%	$929
10	LED Interior Lighting	$34,364	Tenant	Lighting	In-Unit Lighting (LED)	58,867	0	Yes	12.0%	$6,440
	TOTAL	$462,410				208,611	148		42.4%	$22,995

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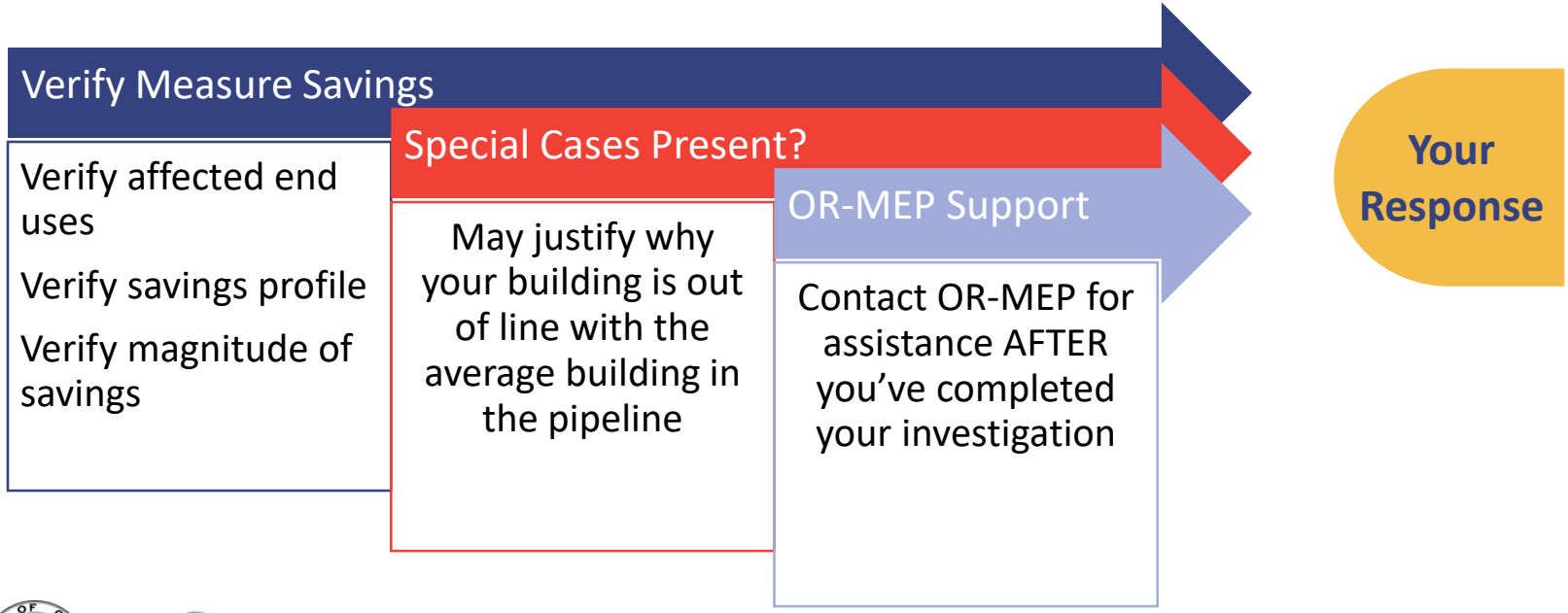
TRC Results you can rely on

MODEL QA
Verify Measure Savings

[OR-MEP] The proposed in-unit lighting savings is higher than what we would expect for a multifamily building. Please investigate possible causes of this discrepancy.

How to Proceed:



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MODEL QA
Verify Measure Savings

Special Cases:

Very Small Apartments <400 sf	• Baseline and proposed appliance and DHW end uses will be higher than average (more appliances and low flow fixtures per sf) • Appliances and DHW contribution to overall savings percentage may be higher than average • Baseline and proposed heating and cooling could be affected due to higher allowances for apartment ventilation per sf

RESOURCES

OR-MEP Support

- Contact OR-MEP for further assistance on your project.

Modeling Software Tutorials and Reference

- eQUEST, REM/Rate

Online Resources

- Department of Energy: https://www.energy.gov/eere/buildings/building-energy-modeling-0
- ENERGY STAR Multifamily (Quality Control Checklist): https://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_mfhr_guidance

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QUESTION BREAK

THANK YOU FOR ATTENDING

Oregon Housing and Community Services Multifamily Energy Program

www.oregonmultifamilyenergy.com

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