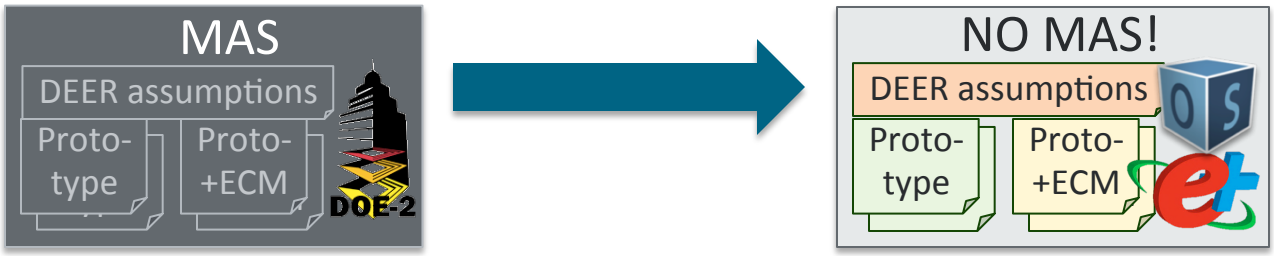
NO MAS: A Next-generation Open Measure Analysis System

A proposal from DOE and the national labs



Jul. 23, 2015

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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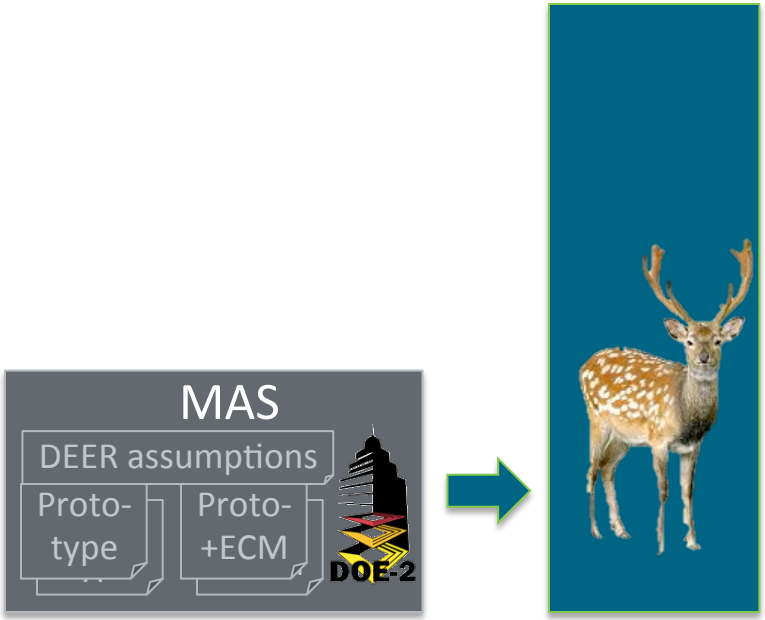
Q&A

- **Q:** Should CPUC replace proprietary DOE-2.2 based MAS with open-source EnergyPlus-based NO MAS to support next generation of DEER and DEER-based programs?

- **A:** Yes – NO MAS will support a more transparent, flexible, maintainable, productive & cost effective system overall.

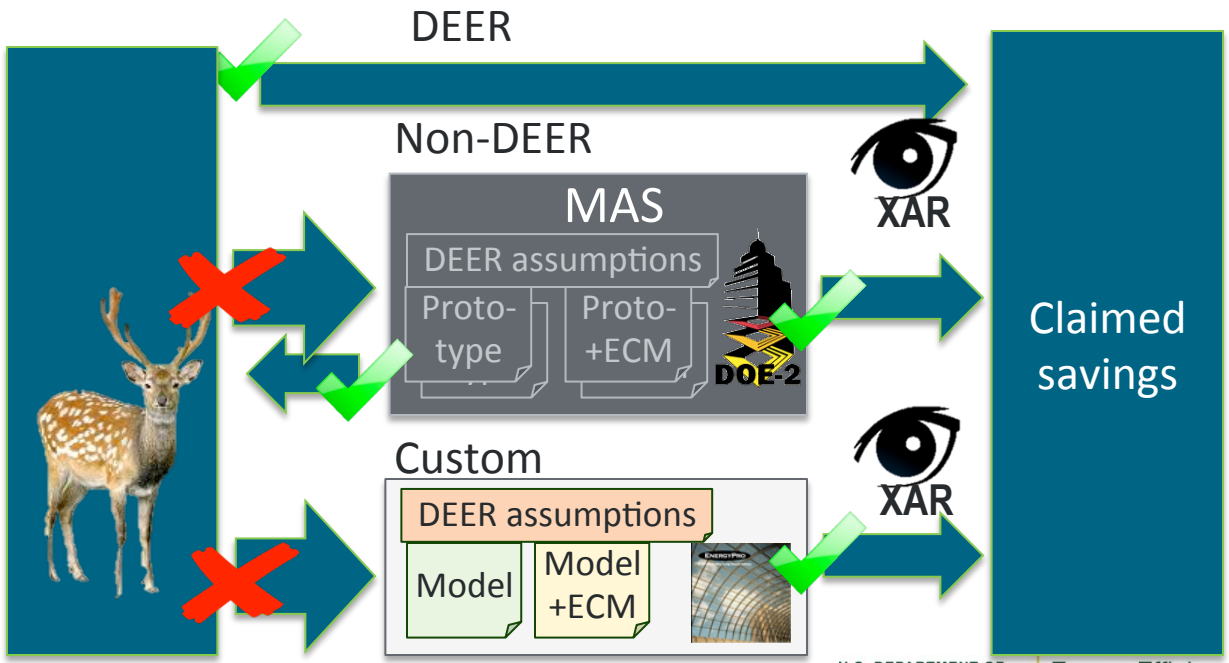
System Overview – New Measures

- **DEER database: deemed savings**
  - <ECM, building-type, vintage, climate-zone> ➔ <energy-savings, cost, ...>
- **MAS (Measure Analysis System):** calculates DEER savings estimates
  - Applies ECMs to California "prototype" building models
  - Encodes & enforces DEER assumptions
  - Evaluates using DOE-2.2 simulation



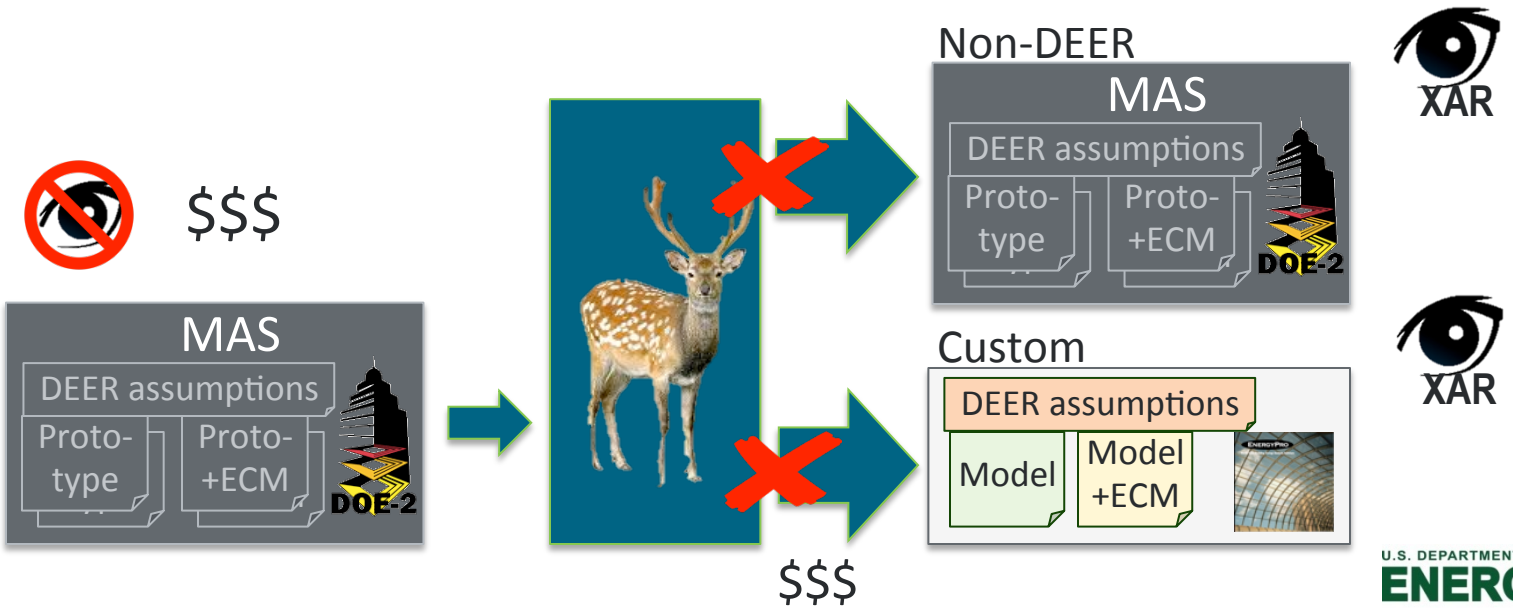
System Overview — IOU EE Programs

- **DEER measure:** use DEER values
  - Claim savings
- **Non-DEER measure:** submit "workpaper" (use DEER assumptions)
  - Ex Ante review: approved? ➔ claim savings ➔ add ECM to DEER
- **Non-DEER measure:** submit model (use DEER assumptions)
  - Ex Ante review: approved? ➔ claim savings



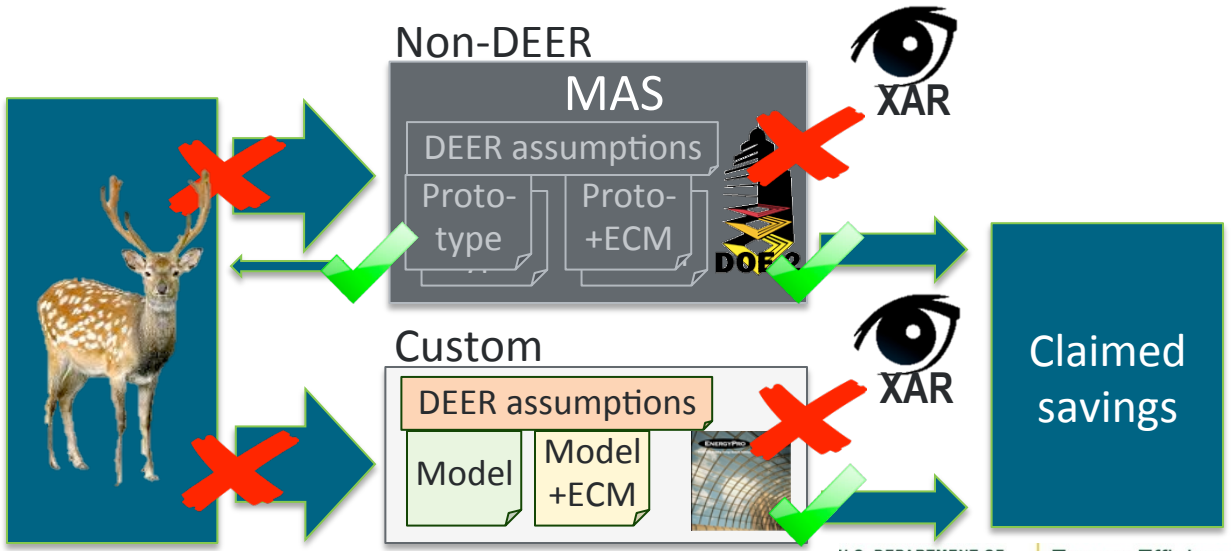
Problems with Status Quo – New Measures

- **MAS is free-to-use but … proprietary (important distinction)**
  - Forces all DEER updates to one contractor (MAS vendor) ➔ increases cost & delay
  - Built-in assumptions & scattered/non-existent documentation ➔ no transparency
- **DOE-2 (MAS simulation engine) has limited capabilities …**
  - Limits DEER expansion to new technologies, *e.g.*, VRF heat-pumps
  - Forces many projects into "non-DEER" & "custom" paths ➔ increases cost & delay



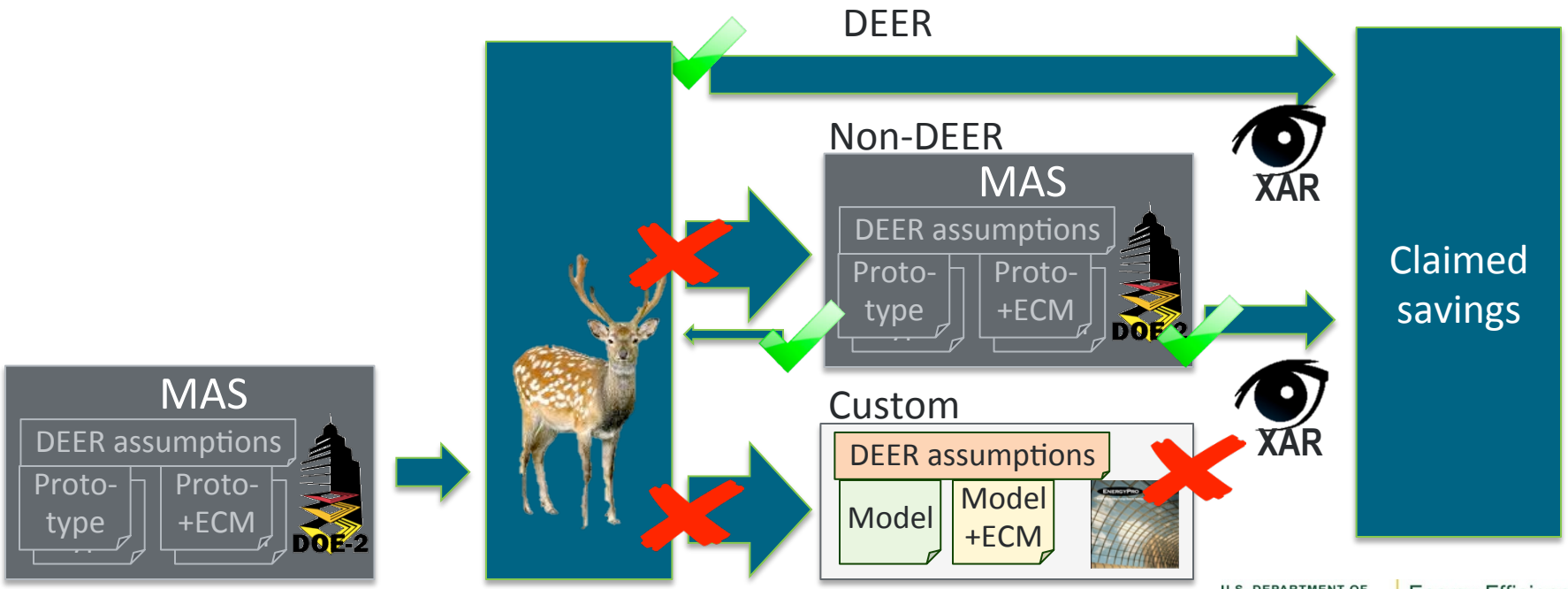
Problems with Status Quo – IOU EE Programs

- **DEER assumptions buried in MAS, only Ex Ante team understands them well**
  - Difficult to incorporate assumptions correctly into workpapers
  - Leaves room for reviewer interpretation ➔ inconsistency project-to-project
  - Workpapers rejected & savings claims derated, sometimes no reason is given
  - New measure approval process is lengthy, expensive & uncertain
  - Makes IOU programs less attractive & less effective
- **Approved measures rarely incorporated into DEER**
  - IOUs keep ad hoc "DEER" ➔ inconsistency, different savings for same measure



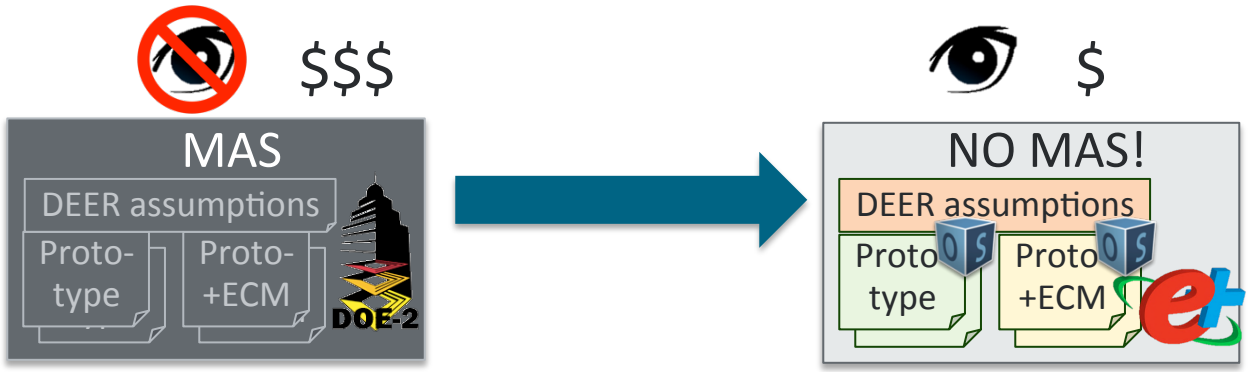
Problems with Status Quo – Ummm …

- **Ex Ante Team led by DOE-2.2 developer**
  - Bias against workpapers developed using non-DOE-2.2 software?
  - DOE-2.2 requires many workarounds ($$) ➔ bias against these also?



Proposal: NO MAS! (Next-generation Open MAS)

- **Replace proprietary MAS with open-source NO MAS …**
  - Make DEER assumptions, inputs & analysis methodology transparent
  - Can use (& modify) for workpapers & custom ➔ reduce delay, rejections & deratings
  - Expand contractor pool for updates & ex ante review ➔ reduce cost & delay
- **… based on EnergyPlus**
  - Advanced modeling capabilities support DEER expansion to low-energy ECMs
  - Reduce workarounds ➔ reduce ex ante review time & cost
  - Align IOUs (CPUC) with public utilities (CEC) ➔ reduce confusion & consultant burden
  - Align DEER with Title24 ➔ reduce confusion & consultant burden
  - Leverage committed, continuing support from DOE

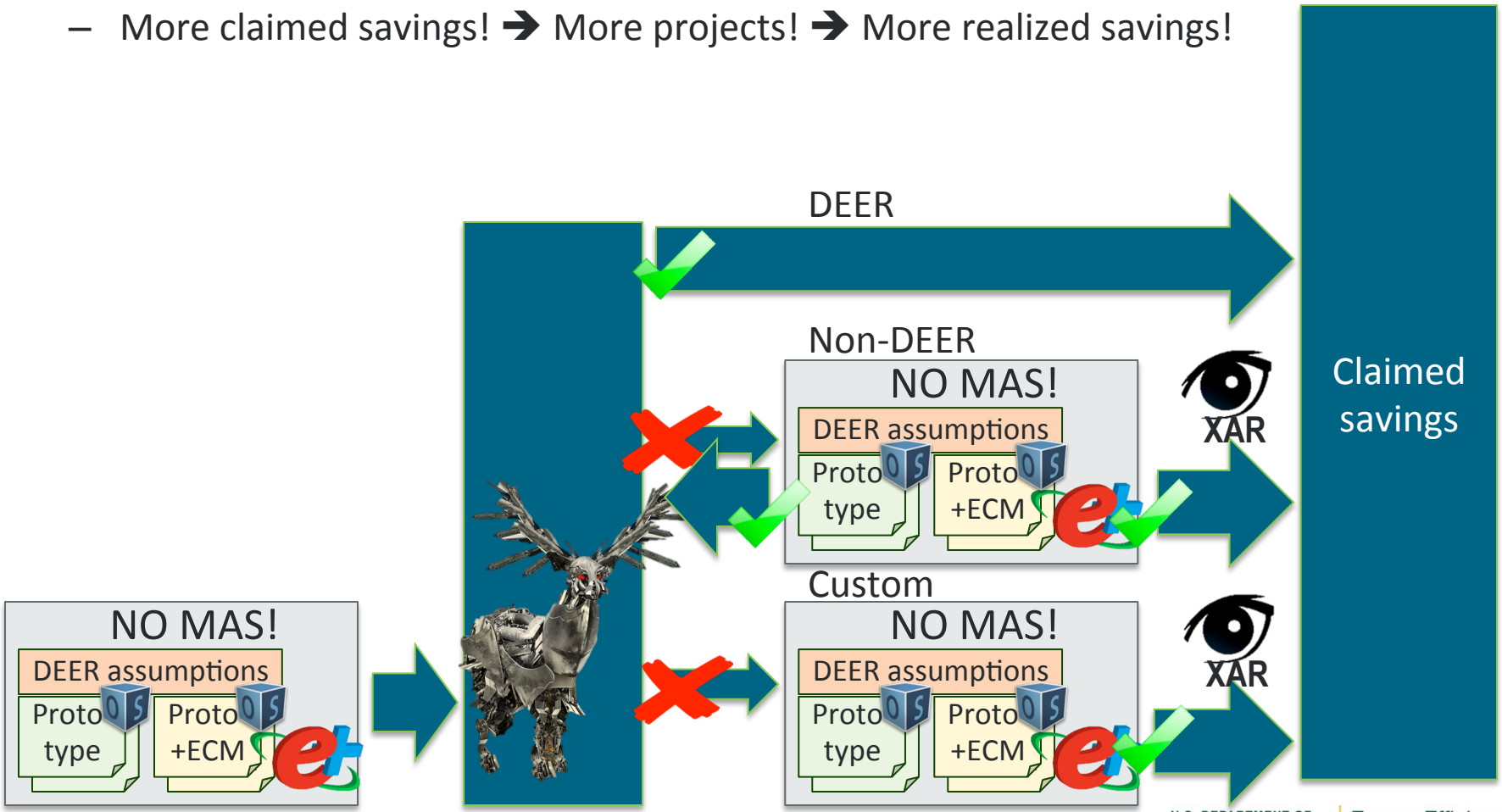


Advanced Modeling Capabilites in EnergyPlus

- **3D geometry & heat-balance solution of radiative & convective heat transfer**
  - Accurate lighting & shading
  - Surface temperatures, thermal comfort, radiant heating/cooling, condensation
- **Integrated heat & mass transfer**
  - Airflow within and between zones, natural ventilation
- **Component-based HVAC**
  - (Nearly) arbitrary system configurations, *e.g.*, VRF & integrated heat-pumps
- **Iterative solution of zone conditions & system response**
  - Accurate treatment of unmet loads & cumulative effects
- **Variable sub-hourly time-steps**
  - Fast acting systems
- **Builtin control scheme library & user-defined controls**
  - Advanced controls, demand response, occupant behavior

NO MAS!

- **An expanded, more comprehensive DEER**
  - More coverage via DEER measures ➔ fewer expensive workpapers
  - Workpapers need fewer workarounds ➔ lighter review & more approvals
  - More claimed savings! ➔ More projects! ➔ More realized savings!



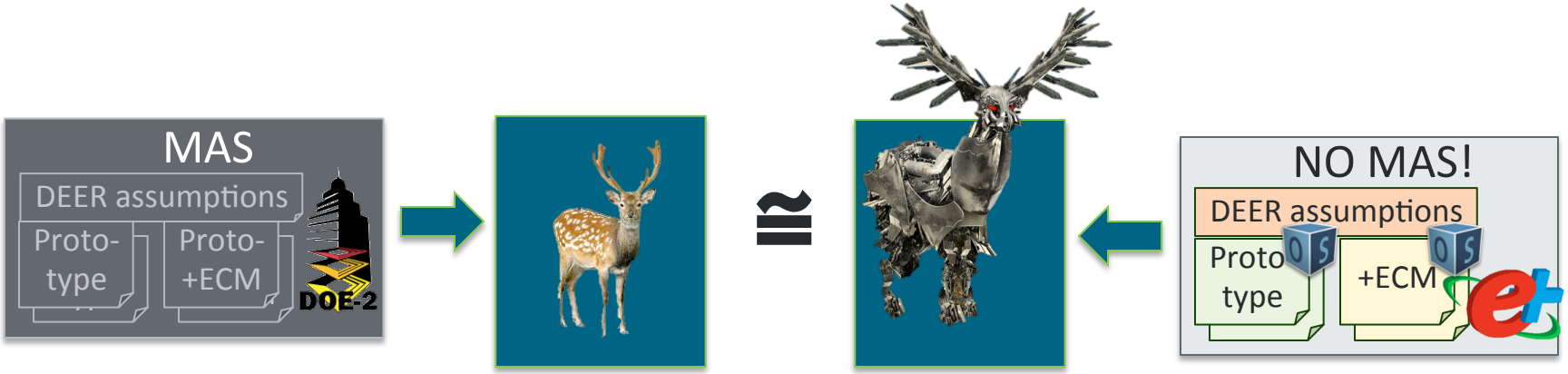
Risks of Switching to EnergyPlus … and Mitigations

- **"EnergyPlus is slower than DOE-2"**
  - EnergyPlus trades execution time for (much longer) modeler workaround time
  - EnergyPlus is getting faster with every release
  - EnergyPlus users don't complain — non-users cite it as an excuse not to switch!
- **"EnergyPlus has not been validated"**
  - All simulation tools have been tested against ASHRAE Standard 140
  - Much easier to validate EnergyPlus than to validate numerous DOE-2 workarounds
  - DOE beginning (at least) three year, $3M empirical validation effort (FLEXLAB)
- **"There are no (free) user interfaces for EnergyPlus"**
  - (OpenStudio), Simergy, DesignBuilder, AECOSim, Sefaira, more
- **"Nobody knows how to use EnergyPlus"**
  - 27,000+ downloads of every EnergyPlus version update
  - Multiple consultants providing training & support
  - 1000+ AIA 2030 Commitment projects: EnergyPlus: 13%*, DOE-2: 28%, TRACE**: 28%
- **What's the risk of not switching? What's the path forward with DOE-2?**

What Will Transition Require?

- **Re-populate "shadow" DEER using NO MAS EnergyPlus models & results**
  - Perform (an independent) cross-walk
- **How long will it take to create NO MAS?**
  - Not long, a lot of infrastructure in OpenStudio

Independent results comparison

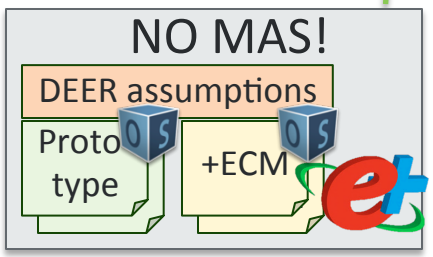


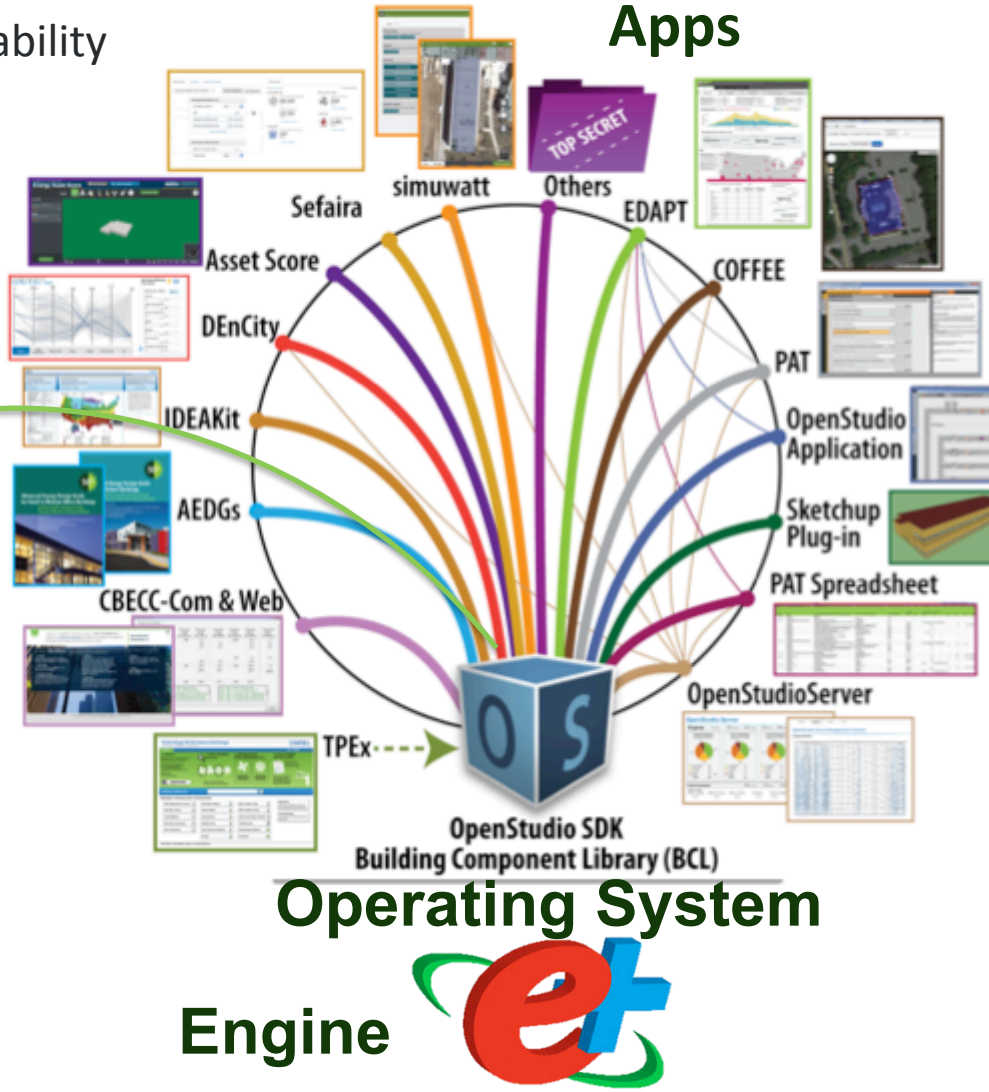
What Is OpenStudio?

- **A software development kit (SDK) for energy simulation**
  - Supports EnergyPlus & Radiance, CONTAM & ESP-r (unclear what DOE-2 would take)
  - Cross-platform, open-source (of course) & supported by DOE
  - Implements common modeling functions: e.g., import geometry, articulate & hook up standard HVAC systems, run simulations on local machine or cloud
  - *Dramatically* reduces effort of developing applications that use energy simulation
- **What applications have been developed using OpenStudio?**
  - OpenStudio application (including SketchUp plug-in)—useful for model creation
  - NORESCO CBECC-Com Title24 (and ASHRAE-90.1 Appendix G) code compliance tool
  - Concept3D Simuwatt tablet-based ASHRAE Level 3 auditing application
  - Sefaira Systems HVAC system selection & sizing application for early-stage design
  - Xcel Energy EDAPT design-assistance program tracking tool**
  - BTO Strategic Prioritization tool**
  - National Grid COFFEE ECM-package targeting application
  - Others in the pipeline
- **OpenStudio is the iOS of energy modeling—a platform for "apps"**

DOE's Energy Modeling Ecosystem

- **Engine—OS—apps layer-cake prevalent in computer systems**
  - Primitives—abstractions—use-cases separated by APIs
  - Shared infrastructure ➔ inter-operability
  - Proprietary & open-source mix
- **Metcalfe's law of networks**
  - Value = number-of-endpoints^2





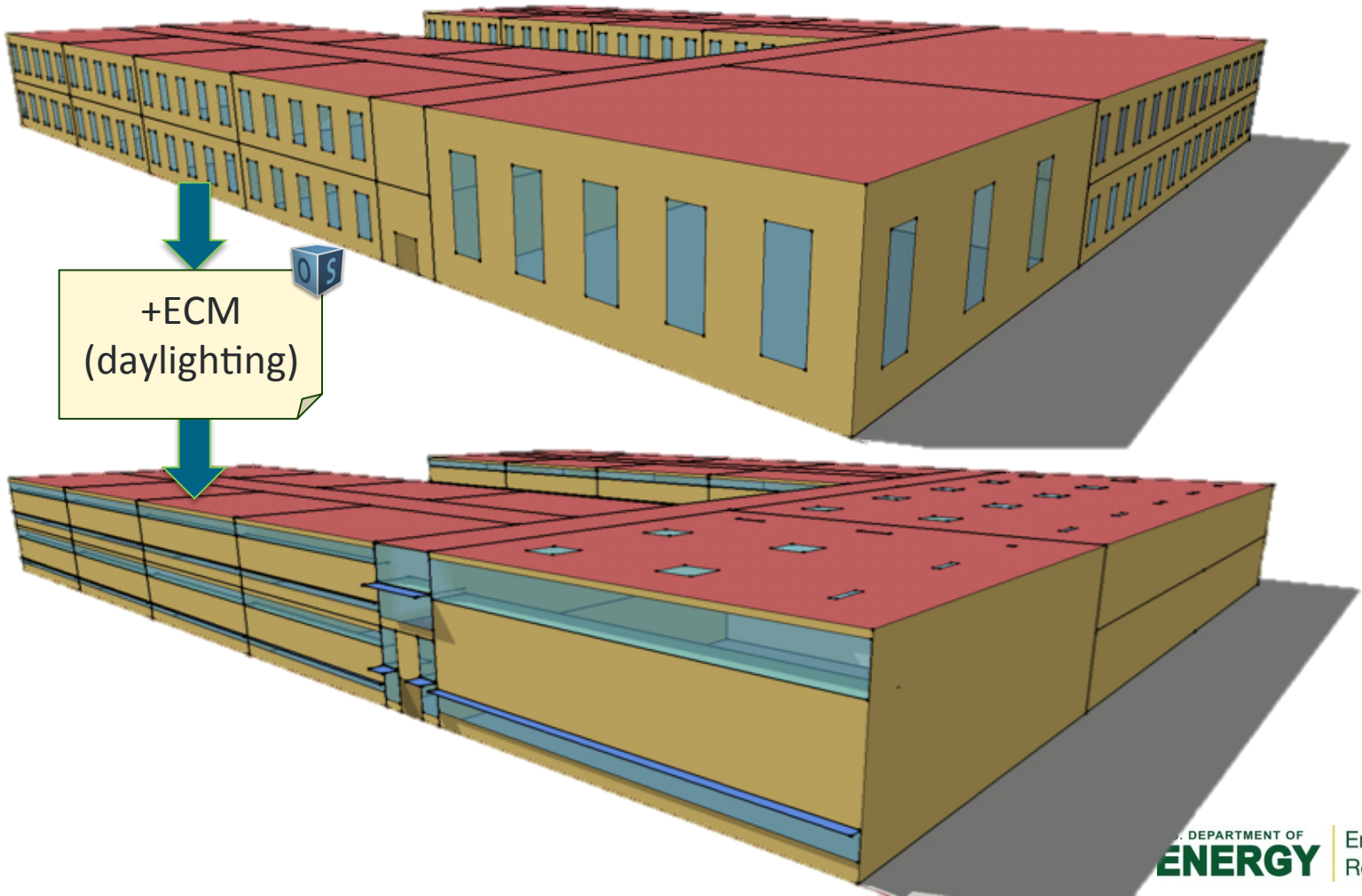
Measures – OpenStudio's Killer Feature

```
#replace exterior wall orig construction with new
model.getSurfaces.each do |s|
   if s.outsideBoundaryCondition == "Outdoors" and s.surfaceType == "Wall"
      #find orig->new construction mapping
      construction_hash.each do |orig,new|
         if s.construction.name.get_s == orig
            s.setConstruction(new)
         end #if
      end #do |orig,new|
   end #if
end #do |s|
```

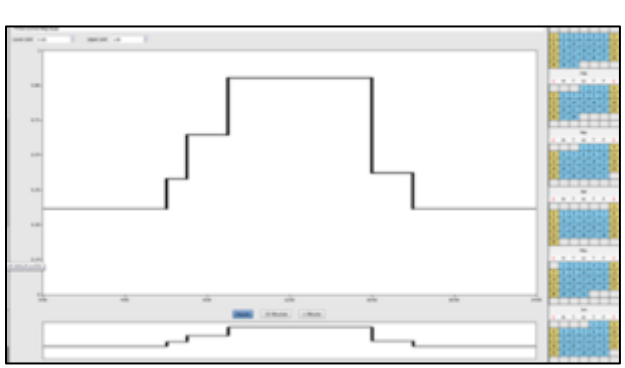
- **"Measures": a dynamic scripting facility like Excel VisualBasic macros**
  - Scripts can access internal building model & simulation results
  - Can transform model, *e.g.*, `change_exterior_wall_construction`
    - Essentially perform an ECM, hence the name "measures"
  - Can query model & results, *i.e.*, custom report or quality-assurance check
  - An open way of extending functionality & no need to hack the SDK itself
  - A way to share knowledge & improve BEM process consistency & quality

Measures – More Like VisualBasic Than Excel Formulas

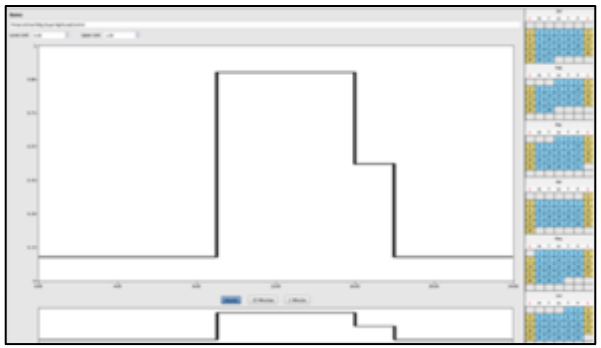
- **Can be arbitrarily surgical and detailed**
  - The full power of the model and the scripting language is available
  - "Portable" to other models & tools

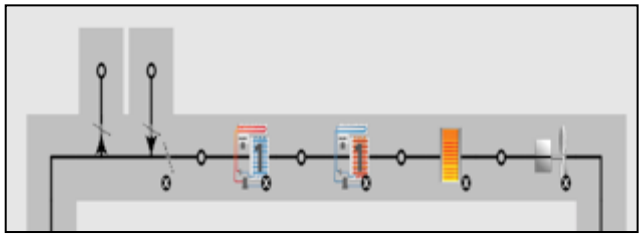


Some More Measure Examples

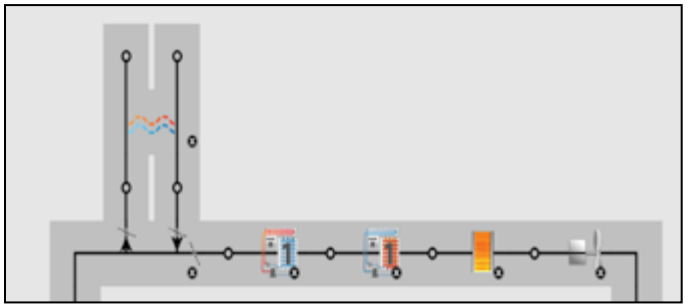


+ECM
night setback



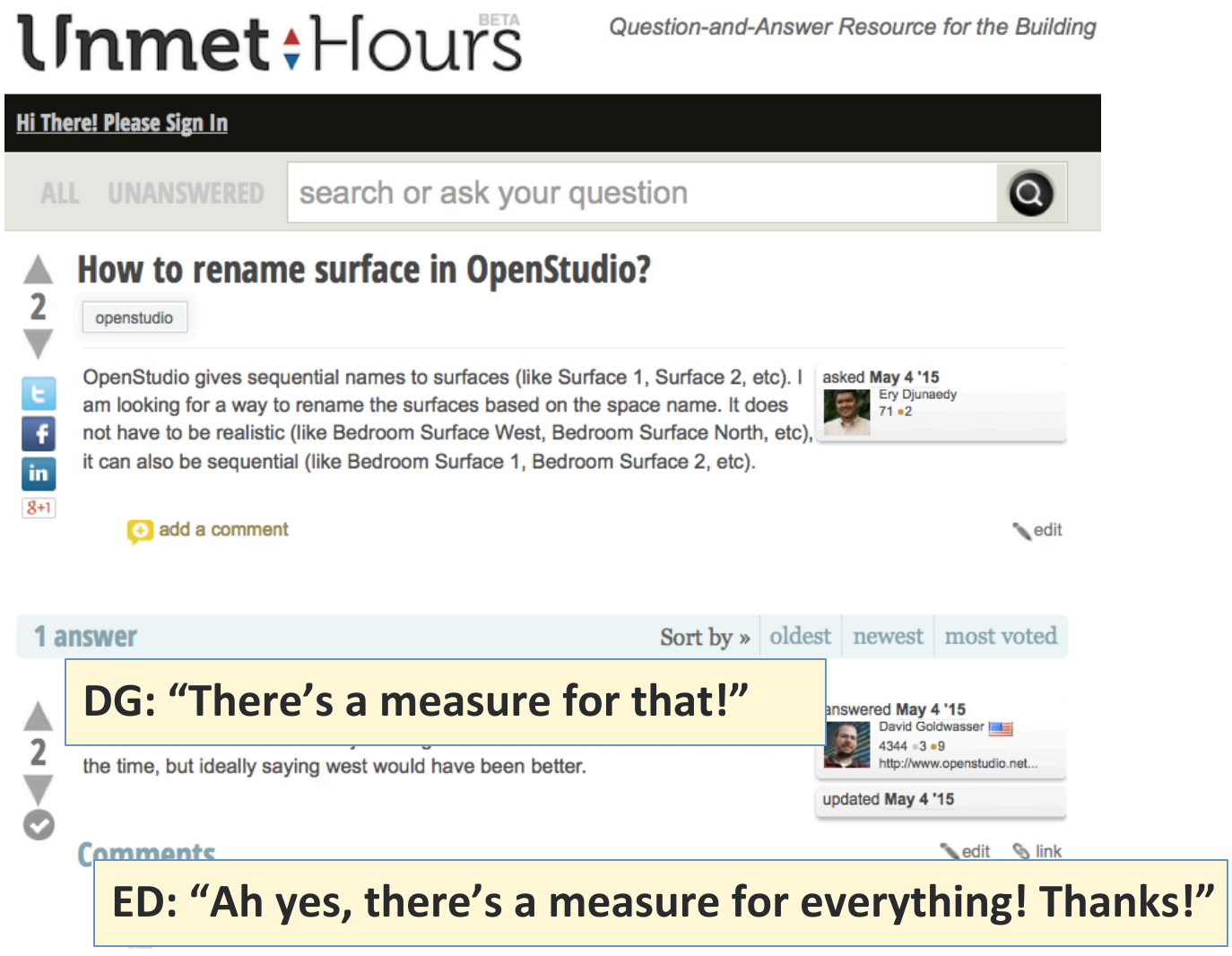


+ECM
heat recovery



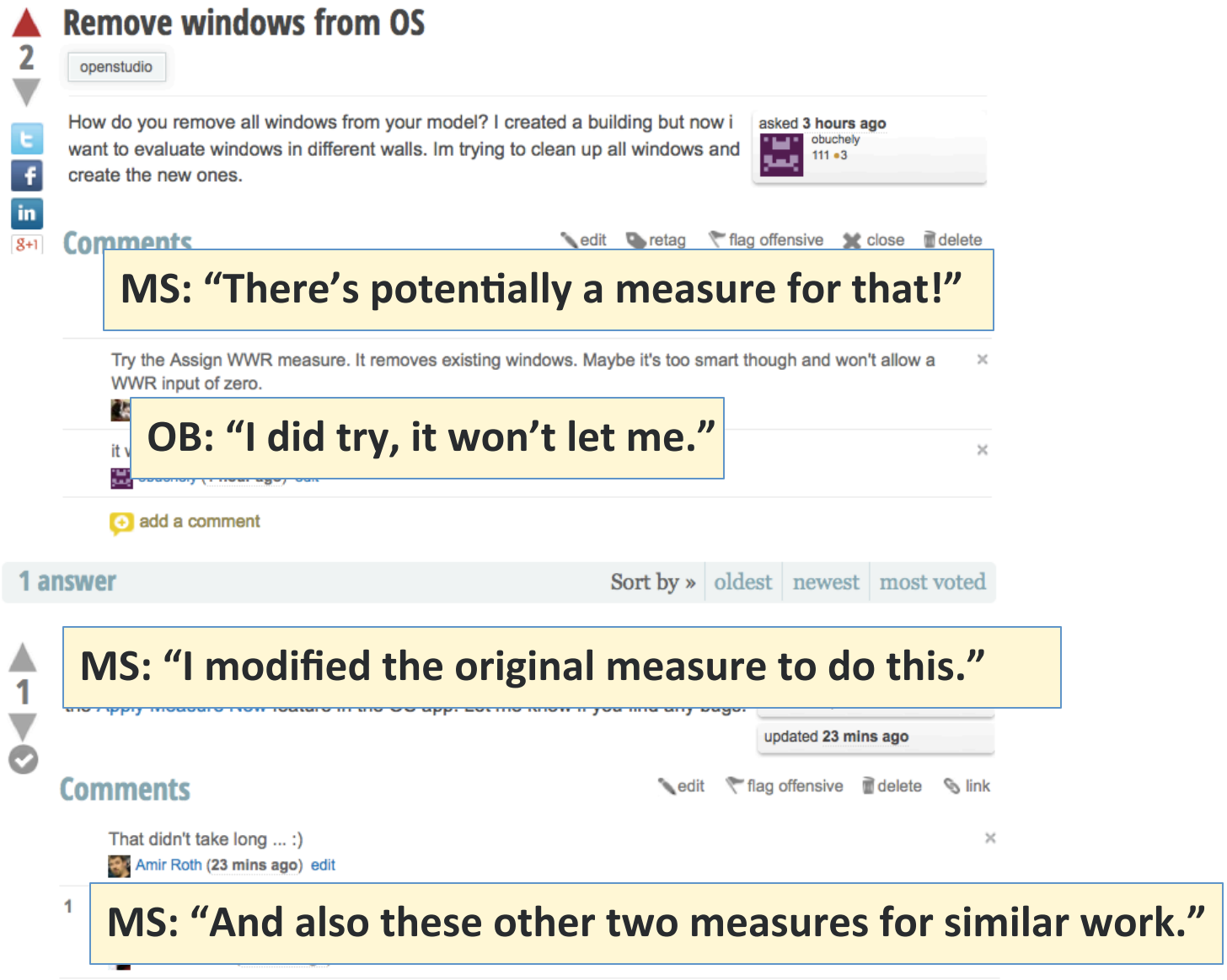
- **185 measures on Building Components Library (https://bcl.nrel.gov/)**
  - Multiple organizations know how to write these
  - BCL has "provenance" ➔ content is as public or private as you want
  - API: embed BCL functionality into your application

There's A Measure For That!™



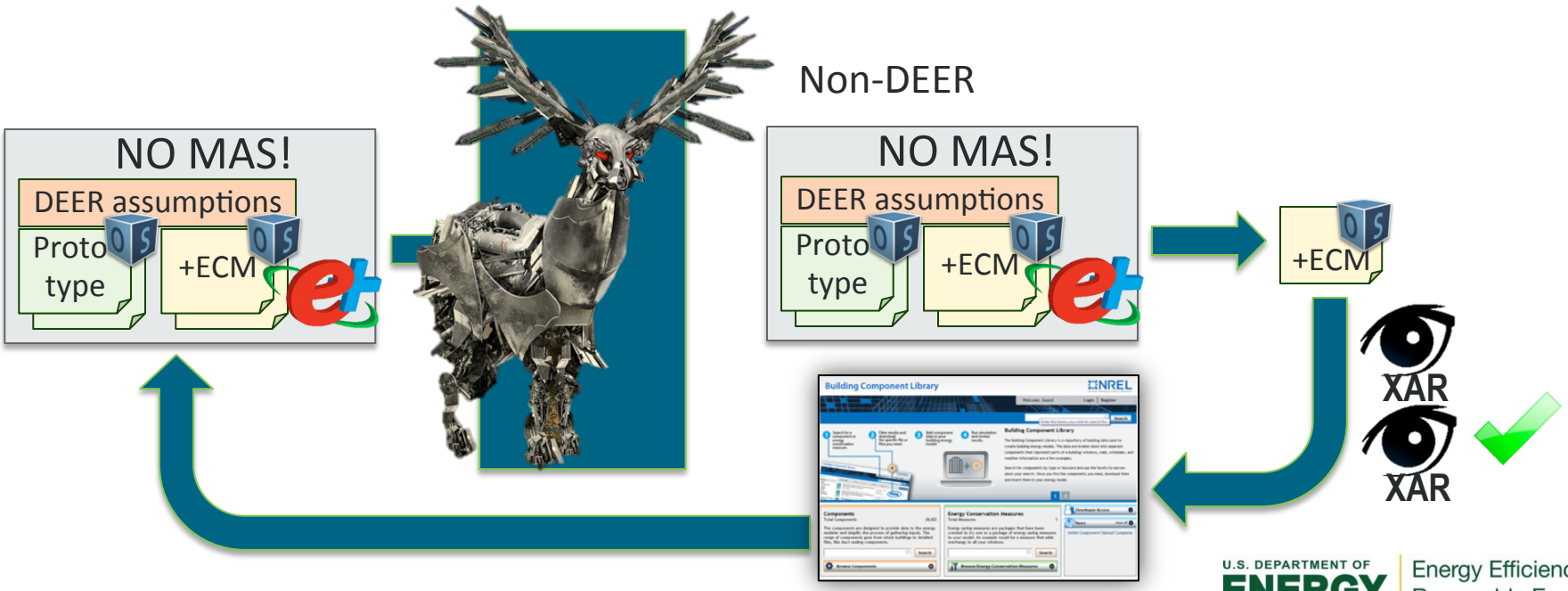
- http://unmethours.com/ **peer-to-peer Q&A site for modeling**

If There Isn't? Just Wait 10 Minutes, There Will Be



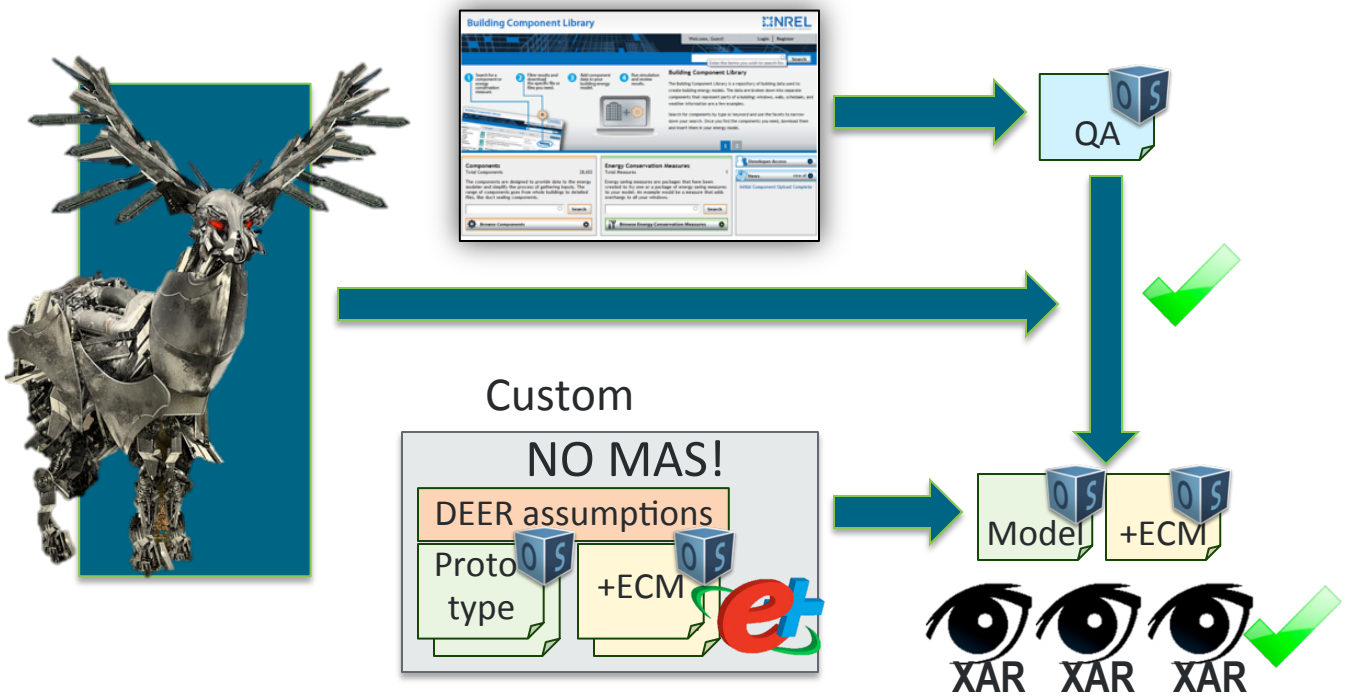
NO MAS Non-DEER Measure Workflow

- **IOU uses NO MAS to develop workpaper & potentially OpenStudio measure**
- **One of multiple contractors reviews workpaper & measure**
  - Potentially develops measure if one wasn't submitted
- **Approved measure applied to all CA prototype buildings ➔ DEER**
  - Published in BCL (tagged with specific program) for use by all



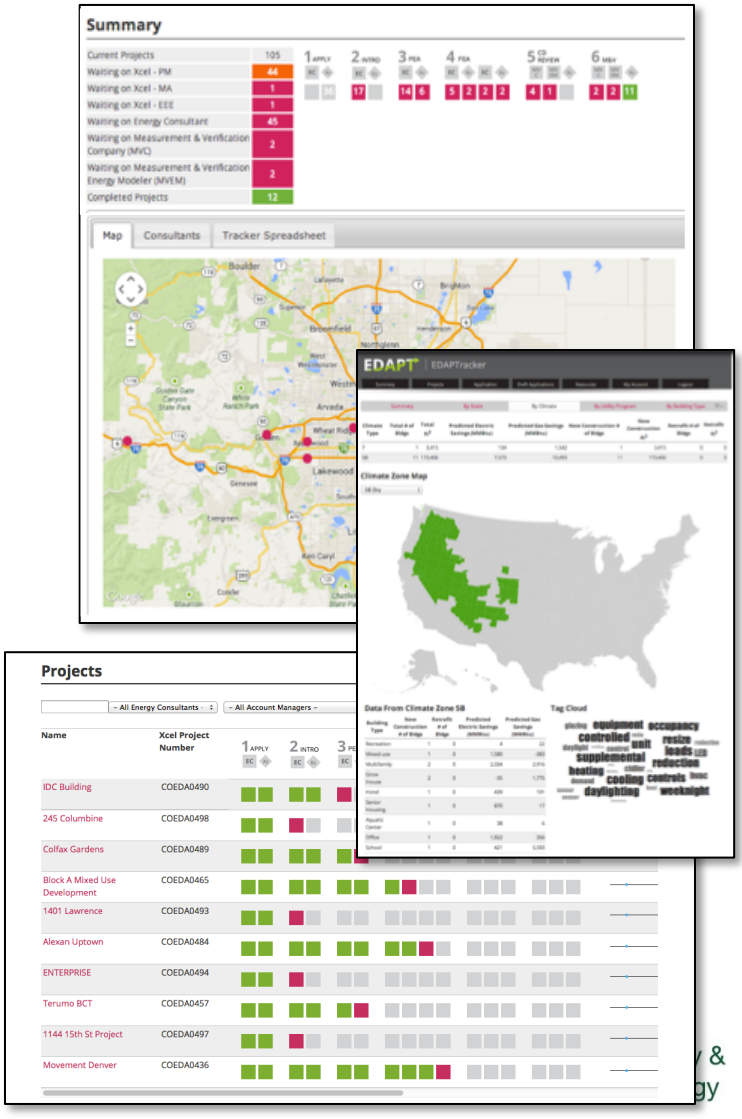
NO MAS Custom Measure Workflow

- **Measures can also query model(s) & simulation results**
  - Perform sanity checks on inputs & results
  - Compare baseline & +ECM model to detect “cheating”
    - Ensures baseline & +ECM differ by ECM only
  - Create report for both submitter & reviewer
  - Can automate initial screening & use reviewer time more efficiently
  - IOUs can perform checks on their own before submission



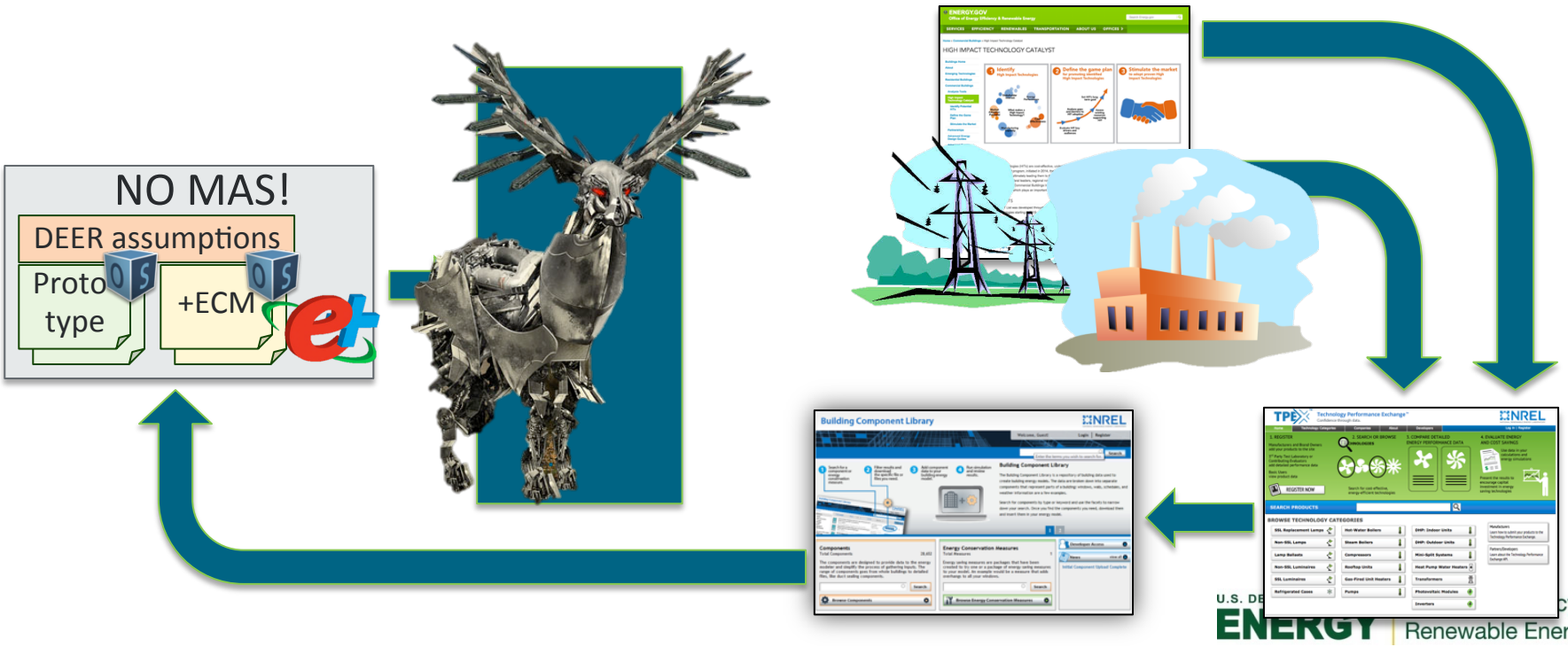
EDAPT: Energy Design Assistance Project Tracker

- **Portal formalizes workflow for Energy Design Assistance (EDA) projects**
  - New construction or retrofit projects
  - QA/QC of model & results (no cheating!)
  - Automated project documentation
  - Communications & approvals
  - Portfolio rollup & reporting
  - Reduced program administration costs
  - Integrated with EnergyPlus/OpenStudio
    - Can accommodate other tools
  - Developed by Xcel Energy
    - In operation for 2 years
    - 51 completed projects, 100+ in pipeline
  - "Bought-back" by DOE
  - Rolling out to Austin, CPS, Oregon Energy Trust



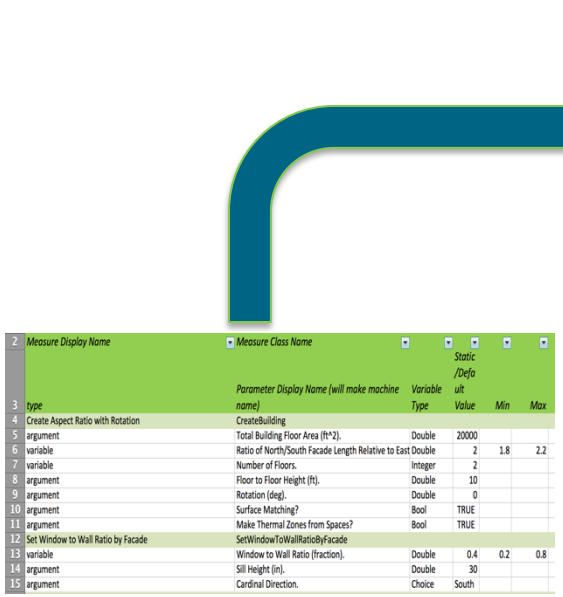
NO MAS New Technology Workflow

- **EnergyPlus has no "hidden" data or defaults ➔ input file is complete audit trail**
- **Building Component Library (BCL) helps collect inputs**
  - 47,000 simulation objects for constructions, equipment, schedules, etc.
- **Technology Performance Exchange** (http://performance.nrel.gov/)
  - Equipment performance data from manufacturers (*e.g.*, LG VRF), tech demos & pilots
  - Translated to BCL simulation objects ➔ tools ecosystem

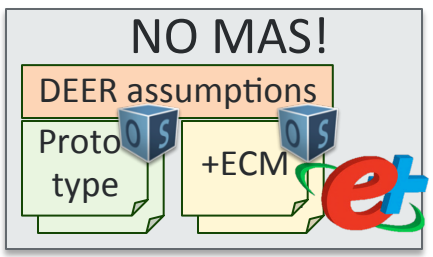


NO MAS Technology Package Workflow

- **OpenStudio supports Amazon EC2 cloud – useful for large studies (~$0.02/sim)**
  - Describe measure combinations you want in a spreadsheet & let 'er rip
  - Can easily & cheaply expand DEER to include packages of measures



	Measure Display Name	Measure Class Name				
3	type	Parameter Display Name (will make machine name)	Variable Type	Static /Default Value	Min	Max
4	Create Aspect Ratio with Rotation	CreateBuilding				
5	argument	Total Building Floor Area (ft^2).	Double	20000		
6	variable	Ratio of North/South Facade Length Relative to East	Double	2	1.8	2.2
7	variable	Number of Floors.	Integer	2		
8	argument	Floor to Floor Height (ft).	Double	10		
9	argument	Rotation (deg).	Double	0		
10	argument	Surface Matching?	Bool	TRUE		
11	argument	Make Thermal Zones from Spaces?	Bool	TRUE		
12	Set Window to Wall Ratio by Facade	SetWindowToWallRatioByFacade				
13	variable	Window to Wall Ratio (fraction).	Double	0.4	0.2	0.8
14	argument	Sill Height (in).	Double	30		
15	argument	Cardinal Direction.	Choice	South		



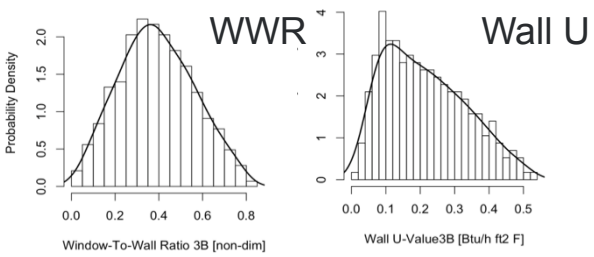
Do not apply ERV

If you want this site EUI

Measures —Not Just ECMs, Uncertainty Perturbations!

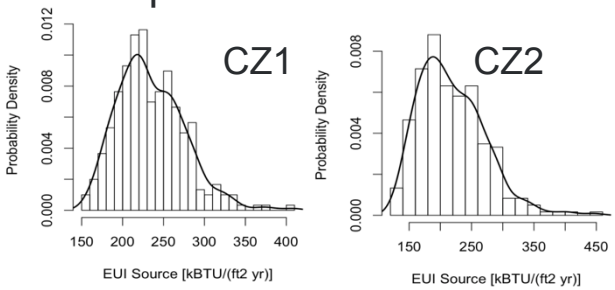
- **Uncertainty analysis ➔ range of savings for range of input assumptions**

input parameter distributions



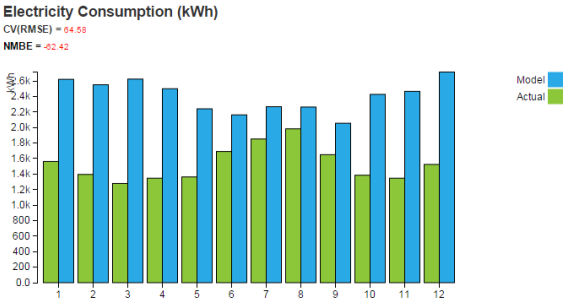
$500

output EUI distributions



- **Calibration ➔ more accurate savings estimates for existing building projects**

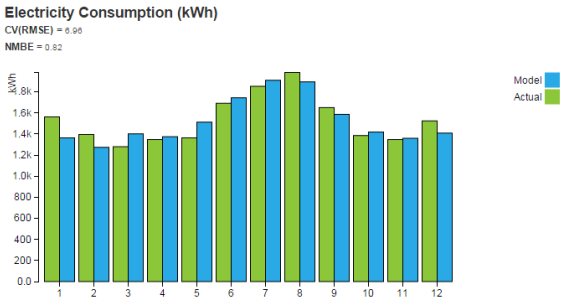
uncalibrated monthly kWh



	1	2	3	4	5	6	7	8	9	10	11	12
Start	1/1	2/1	3/1	4/1	5/1	6/1	7/1	8/1	9/1	10/1	11/1	12/1
End	1/29	2/27	3/30	4/29	5/30	6/29	7/30	8/30	9/29	10/30	11/29	12/30
Actual	1,562	1,395	1,279	1,347	1,363	1,691	1,852	1,983	1,650	1,385	1,347	1,524
Model	2,621	2,551	2,624	2,600	2,241	2,163	2,268	2,264	2,055	2,427	2,466	2,715
NMBE	67.77%	82.89%	105.18%	85.56%	64.41%	27.93%	22.48%	14.15%	24.53%	75.24%	83.05%	78.13%

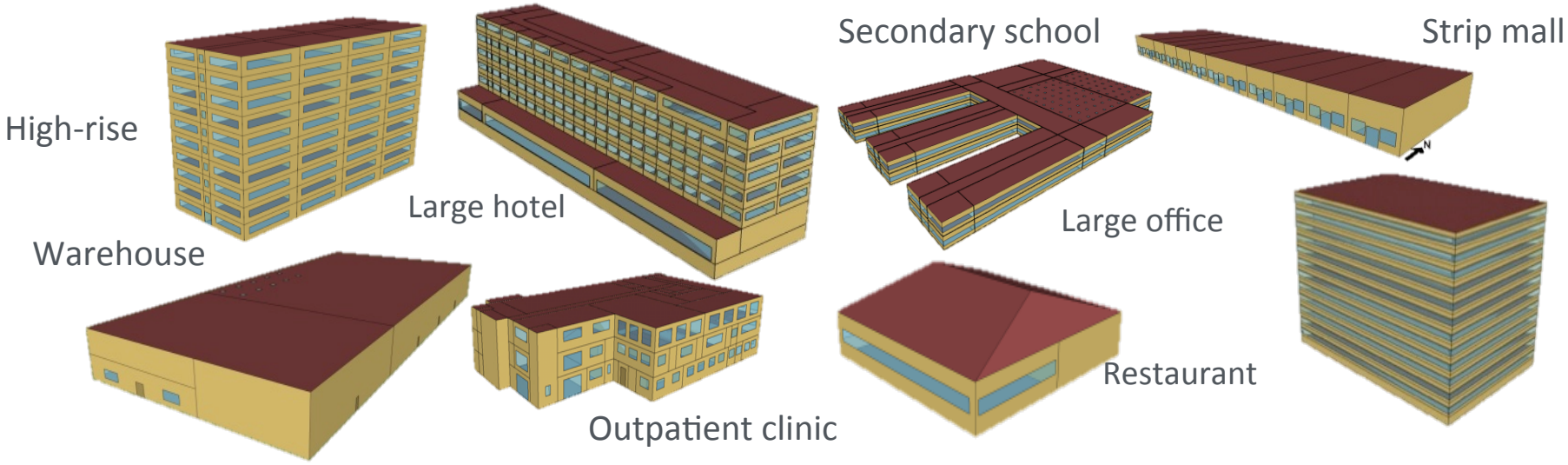
$10

calibrated monthly kWh



	1	2	3	4	5	6	7	8	9	10	11	12
Start	1/1	2/1	3/1	4/1	5/1	6/1	7/1	8/1	9/1	10/1	11/1	12/1
End	1/29	2/27	3/30	4/29	5/30	6/29	7/30	8/30	9/29	10/30	11/29	12/30
Actual	1,562	1,395	1,279	1,347	1,363	1,691	1,852	1,983	1,650	1,385	1,347	1,524
Model	1,363	1,273	1,401	1,374	1,512	1,743	1,909	1,894	1,586	1,418	1,359	1,408
NMBE	-12.76%	-8.76%	9.52%	2.01%	10.93%	3.05%	3.1%	-4.48%	-3.86%	2.37%	0.9%	-7.58%

Last Puzzle Piece: Prototype Models



- **DOE has 6 vintages of these representing building-type x climate-zone**
  - "Old": typical values mined from CBECS (intense consensus/public review process)
  - "New": 90.1 (https://www.energycodes.gov/commercial-prototype-building-models)
  - Heavily used, *e.g.*, for code determinations
- **CA specific prototype models:** implemented in MAS
  - Enough information in published reports to recreate in OpenStudio

What Will Transition Require?

- **CA prototype models:** will take some work, but not rocket science ($)
- **Measures:** many already there, but may need additional ones ($)
- **Independent review** ($$)
- **Ramp up consultants on new ecosystem** ($$$)

Independent results comparison

Why Is DOE Interested?

- **Interested in energy savings & CA programs have large impact**
- **CA is a leader ➔ other states/utilities/regulatory-commissions are watching**
- **We believe in technical & market approach**
  - Single "portable" model for design, code-compliance, beyond code programs, etc.
  - Inter-operable open-source/commercial tools ecosystem
  - Very successful so far ➔ hungry for more success
- **Collaboration & cost-sharing demonstrates impact & leveraging of taxpayer $$$**
  - We have our own "DEER" – Strategic Prioritization Tool (P-Tool)
    - National building stock models + measures
    - Used to choose promising technologies & prioritize investment
    - Used to set technology performance targets & track
  - Other organizations (*e.g.*, BPA) interested in regional "DEER"s
- **"DEER Alternative" presents an opportunity**

Q&A

- **Q:** "Should MAS be replaced by an open-source tool based on EnergyPlus & OpenStudio rather than DOE-2.2?"

YES!

Thank you

Follow-up?
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