EF, MEF and IMEF, Oh My! Coping with Changes in Efficiency Definitions

This poster addresses the question of how to account for older equipment with efficiency ratings reported in deprecated units when conducting analyses with modern tools, or modern equipment ratings with older software or engineering equations. As society places greater emphasis on energy efficiency, additional aspects of equipment energy consumption are incorporated into efficiency standards, yielding incompatible units. In some cases, parties such as the EPA, RESNET, or DOE have published conversion formulæ, but the foundations and fit of these equations are frequently unclear. We have developed alternative conversions and document them and their statistical strength here, along with new regressions for some overlooked units and equipment.

Evaluation work frequently requires searching for efficiency details of specific models of lighting, appliances, and HVAC equipment. While this information is often publicly available, there is no comprehensive repository. This means that analysts must comb through data maintained by a variety of different stakeholders and purveyors, all of whom use different tools with distinct features. In addition, data sources are often incomplete due to the frequent archiving of older models. Finally, when efficiency standards and specifications are revised, not only are permissible levels tightened but sometimes the definitions of regulated units change as well. For example, in the past two decades, clothes washers have switched from EF (Energy Factor) based on energy consumed when in use, to MEF (Modified Energy Factor), which included hot water and dryer energy consumption, and finally to IMEF (Integrated Modified Energy Factor), which added standby power.

To help address these issues and the quandary of analysis with mixed vintage appliances, the authors have created an internal equipment efficiency data warehouse, drawing on sources such as the EPA's ENERGYSTAR Product Finder, AHRI's Certification Directory, and the California Energy Commission's MAEDBS, as well as direct observations from field studies. Using ratings for models of equipment from this database, which were published during various efficiency standard transitions, we developed empirical regressions to derive conversions factors for multiple efficiency ratings. Where available, our conversion formulae are compared with previously published equations.

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This poster outlines empirical regressions of efficiency ratings for equipment that existed during federal minimum efficiency standard transitions from a database NMR has compiled with data from AHRI, CEE, DOE, EPA, FTC, and MAEDBS.

As society places greater emphasis on energy efficiency, additional aspects of equipment energy consumption are incorporated into efficiency standards, yielding incompatible units. Clothes washers were once rated in EF (Energy Factor) based on energy consumed when in use; MEF (Modified EF), which included hot water and dryer energy consumption; and IMEF (Integrated MEF), which added standby power. Alas, older equipment, engineering equations, and software do not disappear when new standards are issued, resulting in the need to convert apples into oranges (i.e., the dotted blue trendlines in the scatterplots below). We present conversions backed by large samples, and for overlooked equipment.
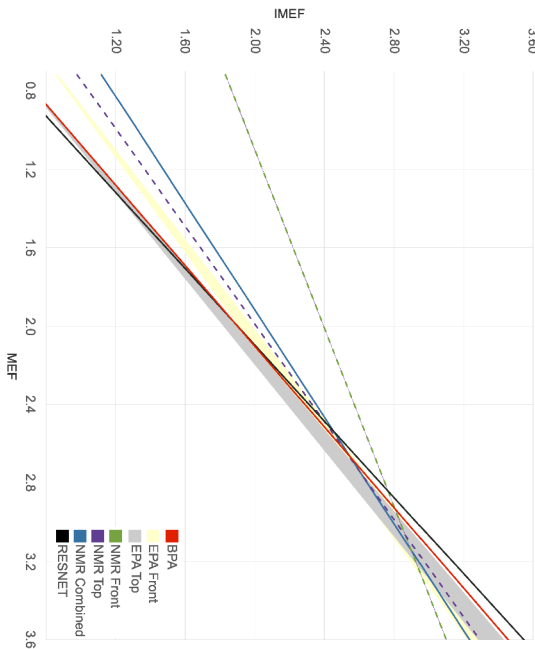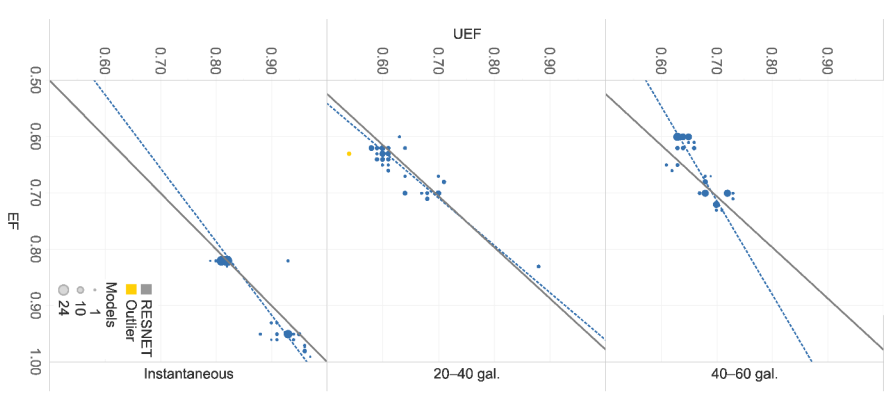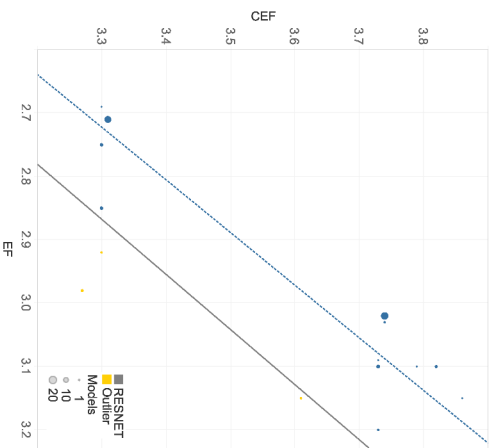
Clothes Washers – Water
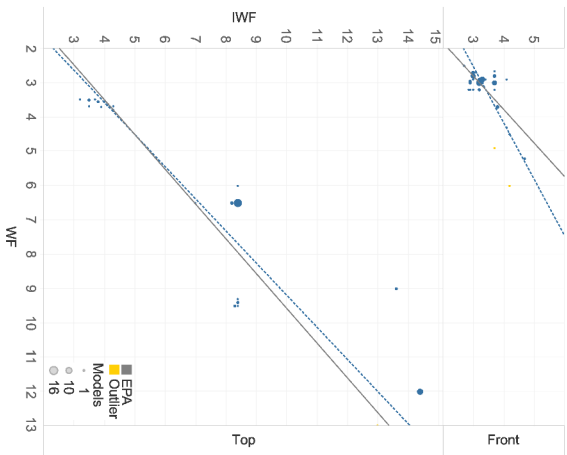
Clothes Washers – Energy
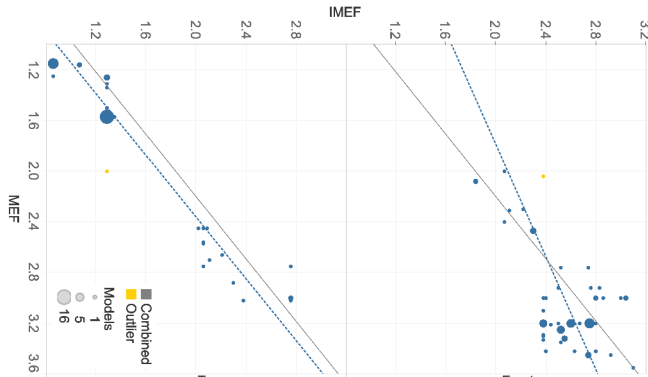
Clothes Washers – Energy: Comparison

Clothes Dryers

Water Heaters (Gas)

Room Air Conditioners

Conversion Formulæ

Category	Source	Regression	n	R²	Change
Clothes Dryer	NMR	CEF=1.2036×EF + 0.0227	61	0.886	2015-01-01
Clothes Dryer	RESNET[1]	CEF=1.1500×EF	1		2015-01-01
Clothes Washer	BPA[2]	Front (≤0.08W): IMEF=0.8979×MEF -0.1311	5		2015-03-01
		Front (1.7W): IMEF=0.8504×MEF -0.0735	5		
		Front (2.3 W): IMEF=0.8400×MEF -0.0705	5		
Clothes Washer (standby) EPA[3]		Top (≤0.08W): IMEF=0.9494×MEF -0.4051	12		
		Top (1.7W): IMEF=0.9980×MEF -0.4051	12		
		Top (2.3W): IMEF=0.9336×MEF -0.3451	12	0.834	2015-03-01
Clothes Washer	NMR	Front: IMEF=0.1072×EF +1.4404	216	0.902	2003-12-01
Clothes Washer	NMR	Top: MEF=0.1850×EF +0.7813	265	0.887	
		Combined: MEF=0.1447×EF +1.0288	481	0.887	
Clothes Washer	EPA[3]	Front: IMEF=0.4502×MEF +1.1926	69	0.379	
		Top: IMEF=0.8217×MEF +0.0567	52	0.923	
Clothes Washer	NMR	Front: IWF=1.0242×WF +0.1172	121	0.836	
		Top: IWF=0.9874×WF + 0.5411	5		
Clothes Washer	NMR	Front: IWF=0.0682×WF + 0.1738	62	0.872	
		Top: IWF=0.6097×WF +1.4492	50	0.623	
		Combined: IWF=1.0685×MEF +0.0601	112	0.868	2015-03-01
Room Air Conditioner	RESNET[4]	Combined: IWF=1.0526×MEF -0.5295			
	NMR	CEER=9280×EER -0.68002	1,231	0.922	2014-06-01
Water Heater (/HP, Res.) DOE[5]		Configuration-specific coefficient, non-standard data	185		2017-06-12
Water Heater (Gas, Res.) NMR		Instantaneous: UEF=0.7668×EF +0.1969	94	0.714	
		20–39 gallon: UEF=1.1924×EF -0.1461	99	0.802	
		40–50 gallon: UEF=0.5988×EF +0.2726	110	0.570	2017-06-12
		Combined: UEF=0.9443×EF +0.0316	303	0.934	
Water Heater (Gas)	RESNET[6] Residential:	Instantaneous: UEF=EF			
		Residential: UEF=1.1030×EF -0.0784			2017-06-12
	Commercial:	Commercial: UEF=0.9995×EF -0.0019			2017-06-12

1 Interpretation on ANSI/RESNET/ICC 301-2014 Clothes Dryer CEF https://www.resnet.us/wp-content/uploads/archive/resblog/2016/01/Interpretation_ClothesDryerCEF_approf1-8-17-v-editfrtopost.pdf
2 ENERGY STAR Clothes Washers Qualified Product List - FY15 (Oct 2014 - March 2015) https://www.resnet.us/wp-content/uploads/archive/resblog/2016/01/Sectors/Residential/Pages/Energy-Star-Appliances.aspx
3 Residential Clothes Washers Direct Final Rule Technical Support Document https://www1.eere.energy.gov/buildings/appliance_standards/pdfs/cw_dfr_tsd_ch5_rev.pdf
4 Interpretation on ANSI/RESNET 301-2014 Clothes Washer IMEF https://www.resnet.us/wp-content/uploads/archive/resblog/2016/01/
5 Department of Energy 10 CFR Parts 429, 430, and 431 [Docket No. EERE-2015-BT-TP-0007] RIN 1904-AC91 Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters https://www.govinfo.gov/content/pkg/FR-2016-12-29/pdf/2016-29964.pdf
6 Interpretation on 301-2014-012 Water Heater UEF https://www.resnet.us/articles/resnet-issues-formal-standard-interpretation-on-water-heater-uef/