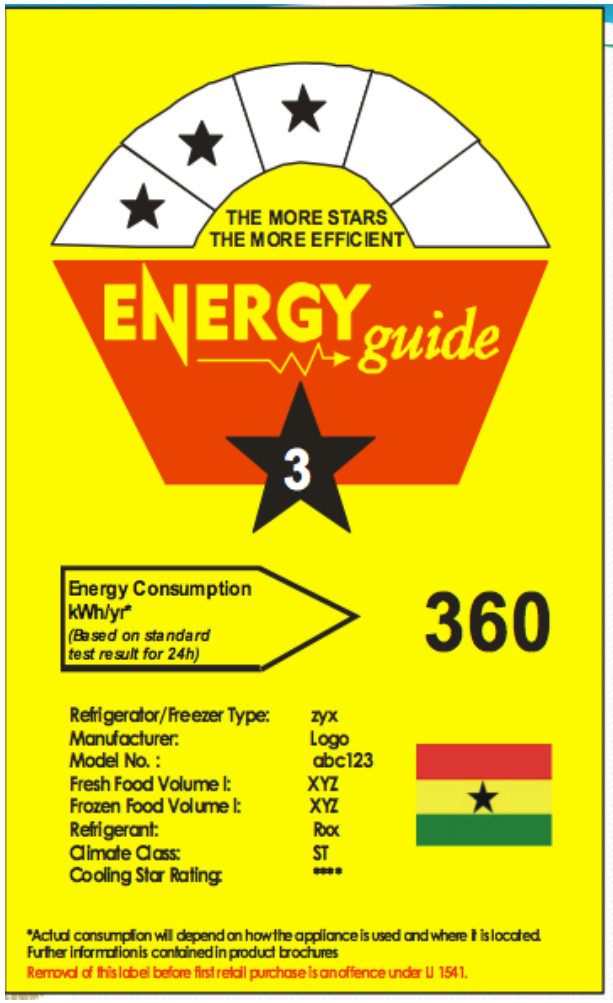
Baseline components are independent

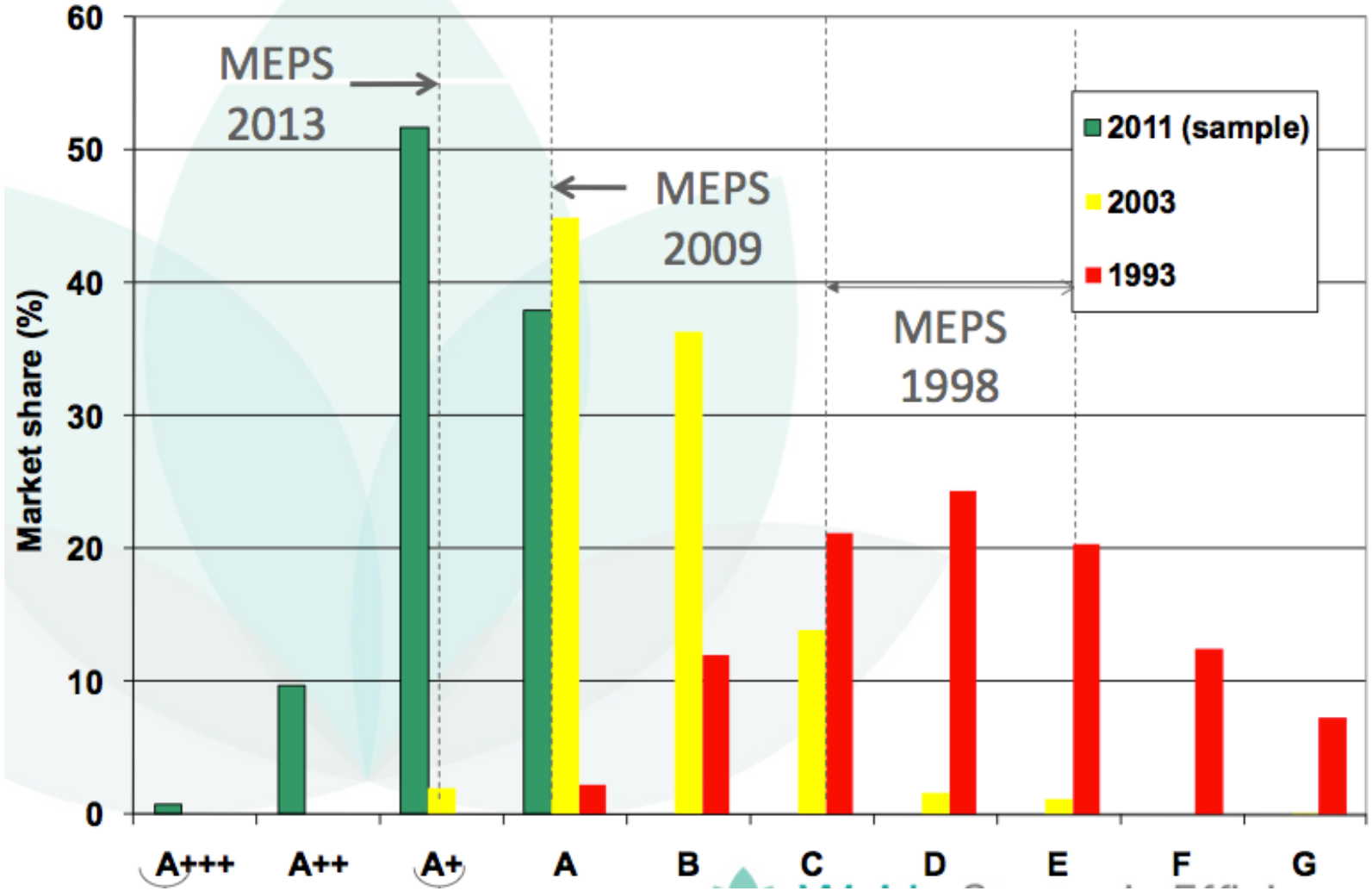
New sales SB component	Replacement SB component	Refrigerant SB new sales	Refrigerant SB replacement	Blowing Agent SB new sales	Blowing ag replacement
capacity seg sales # model #/EE	Household seg model #	Ø volume or charge, sales # model #	Ø volume		
S&L data usage avr	usage avr old fridge test no AC test	HCFC, HFC, HC, HFO inventory	History refrigant shares or recovered vol	HCFC, HFC, HC, HFO inventory	History BA shares
		HCFC, HFC phaseout, calculate Ø leakage	Ø refrigerant recoverable per fridge		Ø BA recoverable per fridge, weigh recovered not feasible
baseline manuf/ retailer/utility	baseline HH type old for new	b. for Montreal ineligibles co. / b. for imports	b. for #appliance recycled	b. for Montreal ineligibles co. / b. for imports	b. for #appliance recycled
additionality			automatic	GWP threshold	Brazil Ghana Singapore



The Ghana Refrigerator Energy Efficiency Label


ENERGUIDE
480 kWh
ENERGY GUIDE
energy consumption
$5000
Energie
340
POWER SAVING GUIDE
ENERGY RATING

Evolution of the EU refrigerator market



Next Steps – Refrigerator Efficiency Project

- 2007 Survey – Average Refrigerator in Ghana consumes 1,200kWh per annum
- New Efficiency Standards limits to 650kWh/annum
- Potential Saving per refrigerator is 550kWh/year
- Assume 1million out of 2.7million refrigerators are removed in 3 years
- Saving is 550x1million =550,000,000kWh
- 324,000 tons of CO_2 per annum

Bureau of Energy Efficiency
Ministry of Power,Government of India

4th Floor, Sewa Bhawan, R.K Puram
New Delhi - 110066 , India

Total 45 different brands

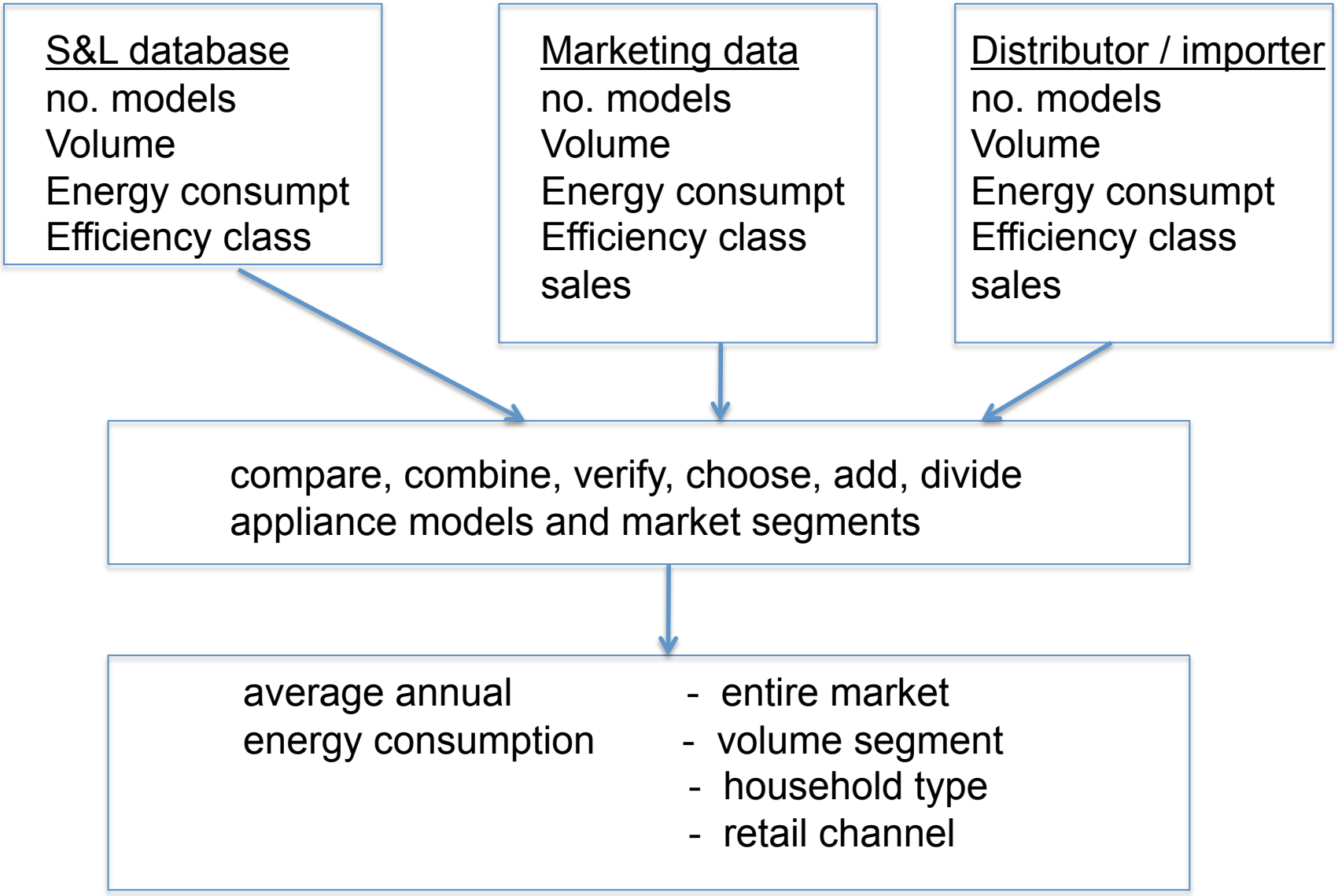
Star Rating List for Room Air Conditioner

S.No	Brand	Type	Model No	EER(W/W) & Equivalent ISEER (Units/Year)	Nominal Marketing Capacity (Ton)	Coling Capacity (W)	Power Consumption (W)	Approval Date	Valid Till	Star Rating
1	GUJRAL	Window air Conditioner	GL15WRT4	2.92	1.5	5232	1790	08-01-2016	31-12-2017	
2	BLUE STAR	Window air Conditioner	3W18LB	2.91	1.4	5030	1730	28-01-2016	31-12-2017	
3	HITACHI	Window air Conditioner	RAW318KUD	3.09	1.4	5100	1650	04-01-2016	31-12-2017	
4	VOLTAS	Window air Conditioner	4011125	2.95	1.4	4900	1661	31-12-2015	31-12-2017	
5	VOLTAS	Window air Conditioner	4011128	2.95	1.4	4900	1661	31-12-2015	31-12-2017	
6	LG	Window air Conditioner	LWA5CS3F	3.01	1.4	4850	1610	16-12-2015	31-12-2017	
7	VOLTAS	Window air Conditioner	4011146	2.95	1.4	4900	1661	30-12-2015	31-12-2017	

GfK

							1875588	1778046	1953324	
							1523 models	1434 models	1290 models	
Productgroup:	COOLING						120 mit En	141 mit E	190 mit E	
Country:	Great Britain						284 kWh arith	280 kwh arith	278 kWh arith	
Channel:	Panelmarket						266 weighted	274 kWh weight	281 kWh weight	
Facts:	Sales Units									
Period:	January 2008 - December 2008, January 2009 - December 2009, January 2010 - December 2010									

	BRAND	MAIN TYPE	ANNUAL ENERGY C	NET	NET	NET	ıry 2008 - Decemb	ıry 2009 - Decemb	ıry 2010 - Decemb	2010
RFA52	HOTPOINT	2 DR FRZ. BTM	343	255	150	105	78,390	76,338	74,611	
CDA 543	BEKO	2 DR FRZ. BTM	334	298	160	138	20,311	32,868	52,163	
CDA563FW	BEKO	2 DR FRZ. BTM	326	238	150	88	17,115	43,507	33,368	
CDA539S	BEKO	2 DR FRZ. BTM	293	197	134	63	23,086	39,723	27,673	
FRE196A							50,442	28,180	10,751	
FFA52S	HOTPOINT	2 DR FRZ. BTM	317	229	150	79	13,245	27,308	35,105	
RLA21 A LF 130/	HOTPOINT	1 DOOR 81 - 9	153	127	127	n.a.	39,346	19,572	16,001	
FF 200 E	HOTPOINT	2 DR FRZ. BTM	361	285	201	84	44,527	17,462	4,190	
CDA 653 F	BEKO	2 DR FRZ. BTM	340	260	166	94	19,544	19,230	22,207	
BAN 12 NF	INDESIT	2 DR FRZ. BTM	325	238	173	65	16,336	13,548	28,834	
MTRF140	FRIDGEMASTER	2 DR FRZ. TOP	222	118	89	29	18,480	26,642	11,339	
TLDA 521	BEKO	1 DOOR >90 C	167	250	250	n.a.	13,389	16,730	24,221	
LA 620	BEKO	1 DOOR 81 - 9	151	130	130	n.a.	16,779	16,900	13,683	
RLA34 LARDER	HOTPOINT	1 DOOR 81 - 9	152	149	149	n.a.	22,099	11,994	12,617	
TRADEBRAND								9,174	32,622	
CDA540W/S	BEKO	2 DR FRZ. BTM	260	208	140	68	12,025	18,613	10,018	
RL-38 SBPS/RL 38 SBPS 1/RL-38 SBTB							402	17,982	21,485	
TDA531W	BEKO	2 DR FRZ. TOP	283	219	142	77	12,838	16,090	9,705	
FF 187 E							28,589	9,114	0	
BAAN 12/BAAN 12 S	INDESIT	2 DR FRZ. BTM	259	303	187	116	9,150	15,014	13,377	
BAAN 10	INDESIT	2 DR FRZ. BTM	230	230	180	50	20,372	9,256	7,232	
KGV28V01GB	BOSCH	2 DR FRZ. BTM	318	253	159	94	16,721	11,896	8,081	
RSAV21	HOTPOINT	1 DOOR 81 - 9	215	105	91	14	18,587	8,944	8,877	
CDA 648							4,757	5,748	24,755	
RA 610	BEKO	1 DOOR 81 - 9	165	114	101	13	10,767	14,070	9,995	
TRADEBRAND							6,342	13,071	15,096	
FFP 187 B							25,301	8,746	78	


S&L database
no. models
Volume
Energy consumpt
Efficiency class
Marketing data
no. models
Volume
Energy consumpt
Efficiency class
sales
Distributor / importer
no. models
Volume
Energy consumpt
Efficiency class
sales
compare, combine, verify, choose, add, divide
appliance models and market segments
average annual
energy consumption
- entire market
- volume segment
- household type
- retail channel

Airconditioners:

models on offer cover the whole size and efficiency spectrum
while sales narrow size and efficiency class,
typically 15 manufacturers cover two thirds of the market
and their models‘ EER all publicly available

➔ some sales data required to show the main models,
efficiency of all main models is known so the
actual efficiency distribution can be established

Refrigerator Problems:

several hundred manufacturers – too many to request data
volume / compartment variability, so x10 number of models

➔ without sales, avr efficiency of models offered even when share of
models‘ efficiency is not known,
approximations for many countries‘ label classes,
sampling for price ranges and retailers.

Airconditioner New Sales Baseline

$$BE_y = EF_{grid} * n_{P,i,y} * hrs_y * \beta_L * \frac{P_{P,i}}{EER_{avr,y}} * \frac{CDD_y}{CDD_{10yr}}$$

1. EER_{avr} calculate average EER or SEER uniform or size ?

   - mandatory / voluntary S&L data coverage of efficiency information
   - without S&L: coverage from China, S.Korea, India with ETL software
   - sales-weighted or models available
   - no testing, too expensive

2. hrs_y monitoring option and defaults option, uniform or household types

   - regional differentiation for annual hours for climate zone

SB Framework for Air conditioner New Sales

conversions for EER and SEER to combine all sources incl. Imports

all use ISO 5151 therefore no need for efficiency class conversions

minimum coverage of efficiency and sales

- suggestions for combining the three data sources
- suggestions for baseline conservativeness reflecting data quality
- suggestions for additionality

Conversions for all AC Test SEER

Single-speed mini-splits (non-ducted)

SOURCE: Clasp 2011

Y	X	α_min	α_ave	α_max
Korea	China	NA	99%	NA
Japan CSPF	China	NA	104%	NA
US SEER non-ducted	China	91%	99%	115%
EU SEER non-ducted	China	86%	112%	128%
China	Korea	NA	101%	NA
Japan CSPF	Korea	NA	105%	NA
US SEER non-ducted	Korea	92%	100%	116%
EU SEER non-ducted	Korea	87%	113%	129%
China	Japan CSPF	NA	96%	NA
Korea	Japan CSPF	NA	95%	NA
US SEER non-ducted	Japan CSPF	87%	95%	111%
EU SEER non-ducted	Japan CSPF	82%	107%	123%
Korea	US SEER non-ducted	86%	100%	109%
Japan CSPF	US SEER non-ducted	90%	105%	114%
China	US SEER non-ducted	87%	101%	110%
EU SEER non-ducted	US SEER non-ducted	75%	113%	141%
Korea	EU SEER non-ducted	77%	89%	116%
Japan CSPF	EU SEER non-ducted	81%	93%	121%
US SEER non-ducted	EU SEER non-ducted	71%	89%	134%
China	EU SEER non-ducted	78%	90%	117%

Refrigerator „New Sales“ Standardised Baseline

$$BE_y = EF_{grid} * n_{P,i,y} * \frac{EEI_{avr,y}}{100} * SAE_P$$

$$BE_y = EF_{grid} * n_{P,i,y} * V_{avr,P} * SEC_{avr,y}$$

SB Framework for Refrigerator

conversions for Annual Energy consumption all test standards

conversions between main efficiency classes EU, China, Korea, Brazil

minimum coverage of efficiency, sales, no models

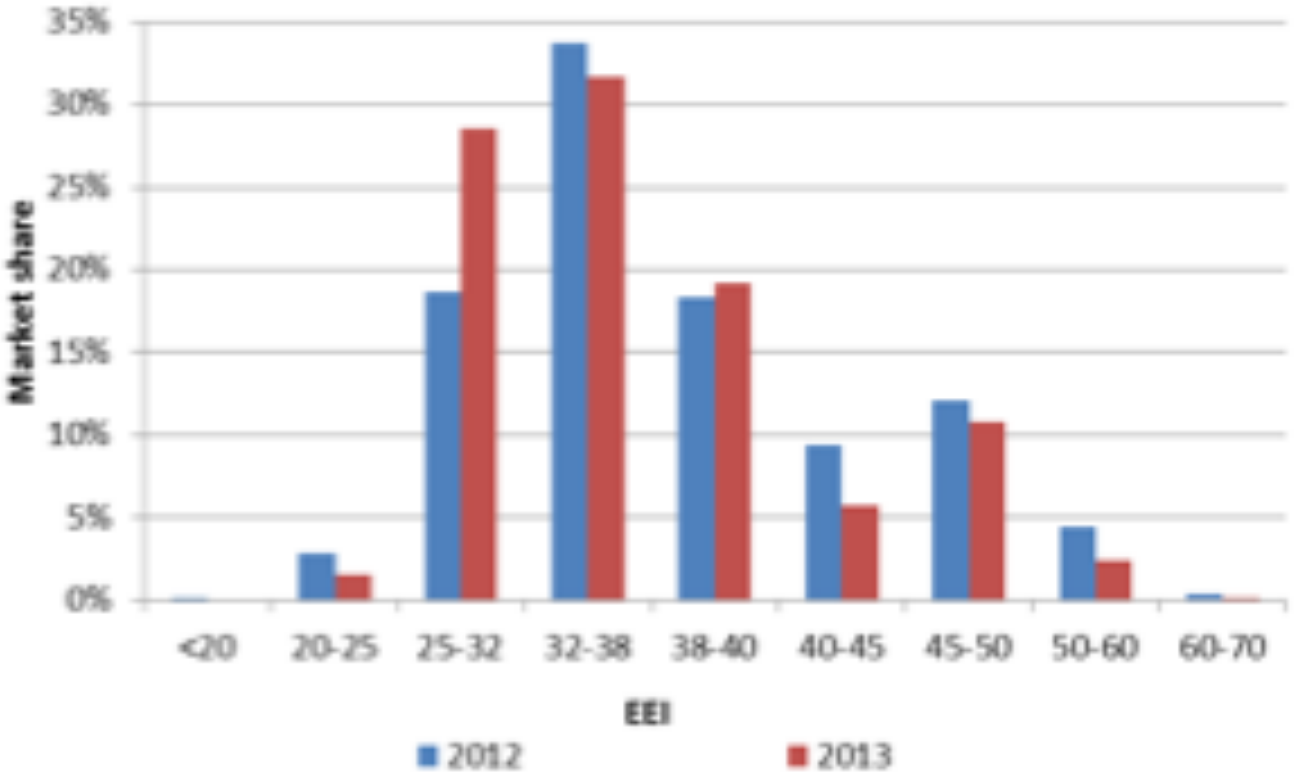
Standardized average specific annual energy consumption

Standardized average Energy Efficiency Index

- suggestions for combining / verifying the three data sources
- suggestions for baseline conservativeness reflecting data quality
- suggestions for additionality

Refrigerators

China



Framework can contain Efficiency Class conversions

$$EEI_{avr,y} = \frac{AE_c}{\left(\left[\Sigma V_c * TF * FF\right] * CC * BI\right) * M + N} * 100$$

Models with EEI data from EU combined with EEI data from China
Or when EEI not available then sales in a efficiency class x mid-class EEI

EU S&L

	M	N
Fresh-food	0.233	245
0-star comp	0.233	245
1-star comp	0.643	191
2-star comp	0.45	245
3-star comp	0.777	303

Label Equivalence

China S&L

	M	N
Fresh-food	0.233	245
0-star comp	0.221	233
1-star comp	0.611	181
2-star comp	0.428	233
3-star comp	0.624	223

Label equivalences:
China Grade 1 ≈ EU class A
China Grade 2 ≈ EU class B * 1.08
China Grade 3 ≈ EU class C * 1.11
China Grade 4 ≈ EU class D * 1.21
China Grade 5 ≈ EU class E * 1.24

Further clarifications:

Additionality suggestions for large scale DSM - define Invest Analysis

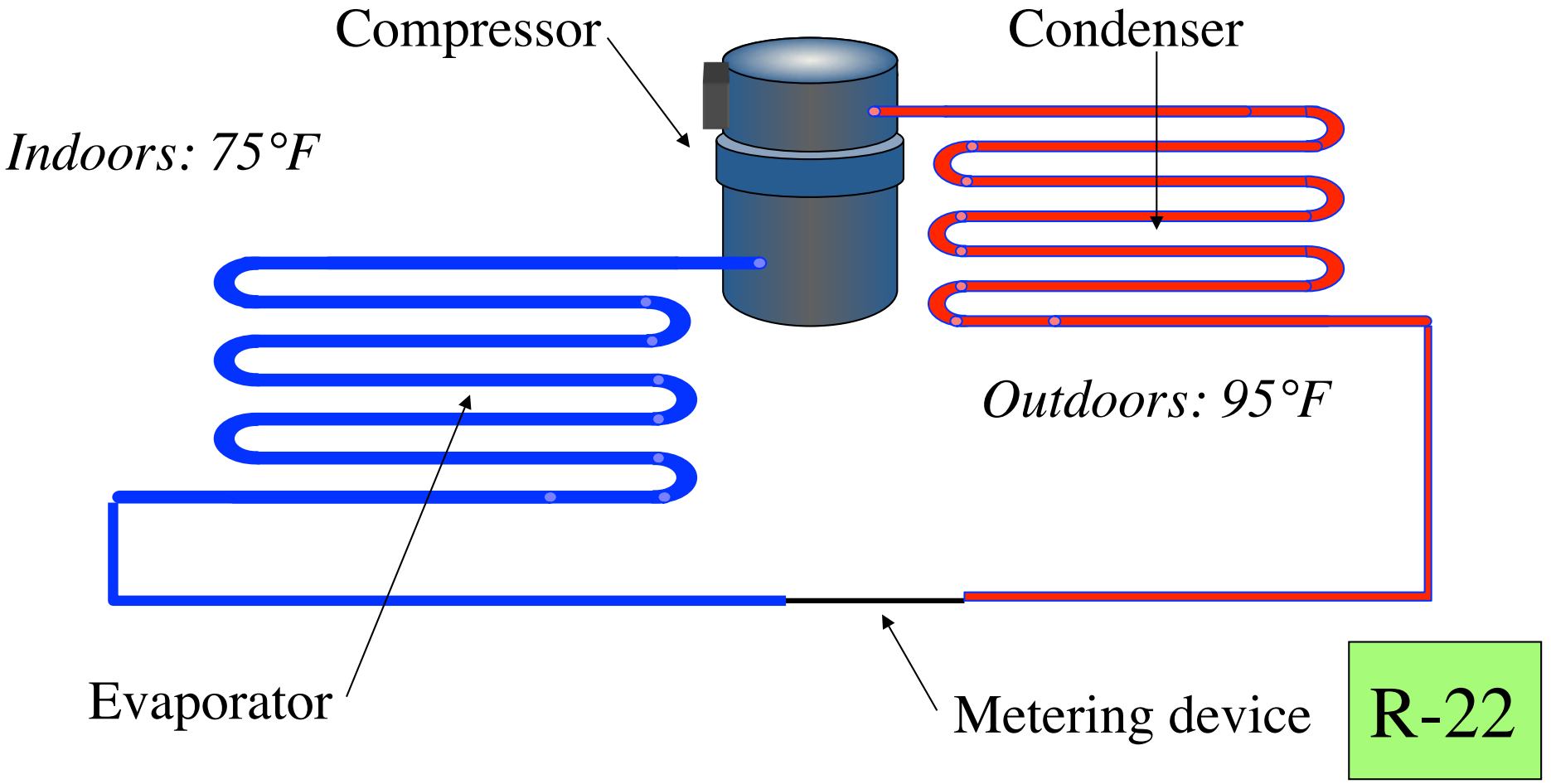
for innovation - define automatic additionality

Refrigerants and Blowing Agents (HCFC-22, HCFC-141b, HFC-134a, HFC-245fa)

insist on DNA asks NOU whether to address that Montreal P. MLF

- substitutes are not differentiated / discriminated
- ineligible enterprises
- additionality oriented on EU‘s F-gas, US-EPA‘s SNAP

PUTTING IT TOGETHER: A WINDOW UNIT EXAMPLE



REFRIGERANTS MUST BE DETECTABLE

- Soap bubble solution – pinpoints leaks
- Halide leak detector – uses an open flame
- Electronic leak detectors – general area leaks
- Ultraviolet leak detectors – pinpoints leaks
- Ultrasonic leak detectors – uses sound waves

California

Compliance Offset Protocol Ozone Depleting Substances

Emission Reduction Measurement and Monitoring Methodology for the Transition to Advanced Formulation Blowing Agent in Foam

Québec

Destruction of Ozone Depleting Substances in Insulating Foam or used as Refrigerants removed from RAC

Mexico

Mexico Ozone Depleting Substances Project Protocol

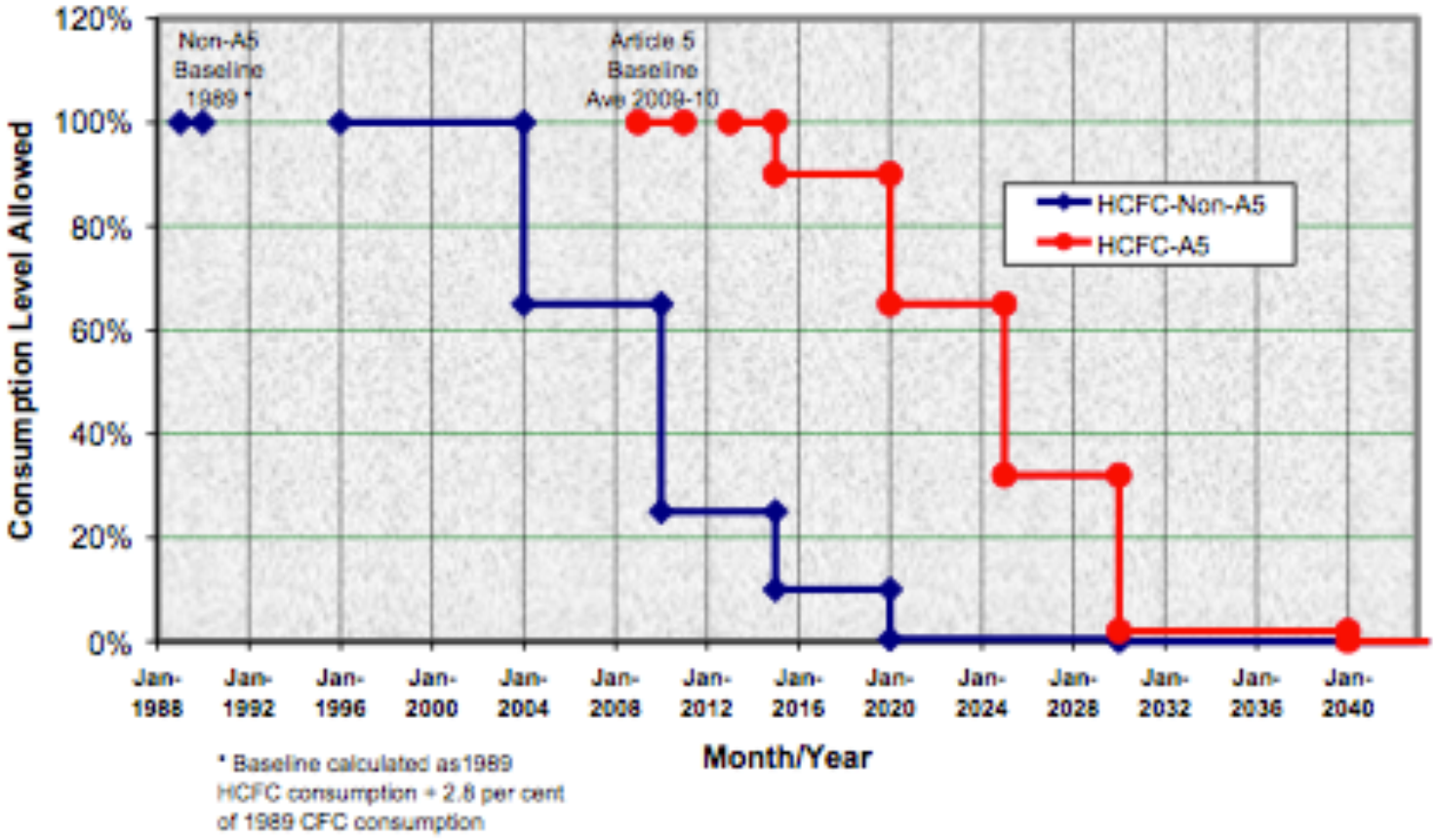
VCS

Infra-red Automatic Leak Detection Project Methodology

Switzerland

Swiss Charter – Climate Protection by Recycling

HCFCs (Annex C/I) Consumption Reduction Schedule



Task 4 AC Data Coverage to Prescribe

ideally to control

S&L data accessible ⟷ importers / wholesalers

realistic to combine

China, SKr, Jap >70%

sales and efficiency for all	verify averages
sales and efficiency class	
no sales, most efficiencies	sales-weighted EER
no sales, most efficiency classes	sales per class
sales but no efficiencies	sales per size
sales but no efficiency classes	sales per Ch, Kr class

$EER_{ISO} = EER_{NAFTA} / 1.0096$
$EER_{ISO} = EER_{Korea} / 1.012$
SEER .....
copied CNIS, Kemco, BEE

Airconditioners no testing

Possible Conservativeness to Allow Market and Behaviour

Data available

all sales all efficiencies	survey GfK	no sales 30% efficiencies

Baseline Suggestions:

% above avr		lower end % of avr

Additionality Suggestions:

EER at Top 20% sales		EER at Top 20%models highest EE class mid EU class A

Airconditioner SB Framework specifies

Mandatory S&L complete	**Mandatory S&L partial**	**Voluntary S&L**	**Import with sales ex GFK data or Ghana**	**Import without sales**
Min coverage sales Min coverage efficiency or EE class	Min coverage sales Min coverage efficiency or EE class	Min coverage sales Min coverage efficiency or EE class	Min coverage sales Min coverage efficiency or EE class max national production	Min coverage efficiency or EE class max national production with data, w/o
default usage parameters benchmarks possible fixed, VSD Additionality highest class avr	define for impact, ex China class 1, EU class A, avr Japan	EER_{avr} corrected Ex: Data from 30% of total sales = lowest is market avr		

Refrigerator SB Framework specifies

Mandatory S&L partial	Voluntary partial	Import with sales ex GFK data or Ghana	Import without sales	Imports data and test of unlabeled	No import data, only test of sample
Min coverage sales Min coverage efficiency or EE class	Min coverage sales Min coverage efficiency or EE class	Min coverage sales Min coverage efficiency or EE class max national production	Min coverage efficiency or EE class max national production with data, w/o	Coverage China and EU label data Test sample	Coverage of geography of retailers, prices (from online shops) and volumes
EE>60%: $SAEC_{avr}$ kWh/l 120-400 l benchmarks possible additionality	define on impact: ex China class 1, EU class A, avr Japan	EE>60%: $SAEC_{avr}$ kWh/l 120-400 l Ex: Data from 30% of total sales = lowest is market avr	EEI_{avr} Label equiv Test conversions >70%sales Avr imported models 30%class Avr national models 30%class	EEI_{avr} Label equiv Test conversions	Simplified test protocol only when no importer data

Refrigerants between Convention, KP and MP

all NAI funding HCFC reductions for 10 more years
all NAI will soon fund HFC reductions for 15 more years

HFC reductions are credited in KP while MP funds phase-down
many new replacements for HCFC and HFC are appearing

➔ „market leakage“ because HCFC and HFC volume limits cause market actors to anticipate
- their competitors changing refrigerants
- their prospects of exporting (SNAP 21, EU F-gases)
- new government regulations

➔ market shifting leakage and activity leakage
new meths for refrigerants in ACR (and blowing agents)

EB34 only when HCFC will rise = cannot occur while NAI are running HPMP
now HPMP increase HFC = credit hypothetical HFC
broader: incentive context under HPMP and future „HFC-MP“

Refrigerants SB NAI country with AC manufacturing

Baseline	Project scenario
AC with HCFC-22	AC with HFC-32
AC with propane	AC with propane
AC with R410a	AC with R410a
AC with HFC-134a	AC with HFC-134a
	AC with HFO
some receive HPMP funds	some receive HFC funding
some ineligibles changed on their own	ineligibles on their own

SB created

SB Framework defines: data coverage for model#, sales#
baseline aligned with HCFC phaseout

Plausible Scenario for marginal new non-HCFC Airconditioner

Baseline scenario

most NAI use the largest share of HCFC for servicing HCFC-22 equipment
some NAI use largest share of HCFC for manufacturing HCFC-22 equipment

when a project reduces HCFC-22 equipment by replacing equipment with HC or HFO or NH_3 or CO_2 using equipment, achieving HPMP is made easier

HPMP servicing rules remain and govt will use all its HPMP budget

➔ a PP's effort reduces the volume of HCFC-22 imported and produced

➔ No leakage outside of boundary

Airconditioners
- charge volume data feasible manually (from S&L)
- without data, approximate with:
  charge (kg) = (0.18 + 0.06 * EER) x cap (kW)
- manufacturers leakage data
- measure leakage sample
- IPCC default leakage
- inventory of different refrigerants / total sales

$$Lk_{Mar,y} = \Sigma \left(n_{P,i,y} * Q_{REF,i} * Lk_{REF,i} * GWP_{REF,i} \right) \div \Sigma n$$

$$PE_y = n_{P,i,y} * \left(Q_{REF,P} * Lk_{REF,P} * GWP_{REF,P} - BE_{REF,y} \right)$$

Baseline has big jumps with GWP

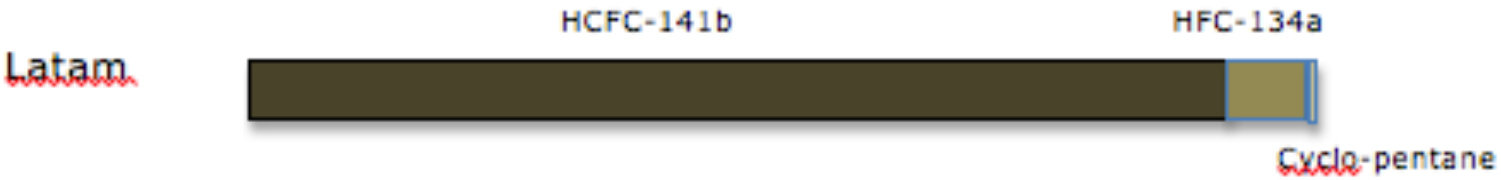
Refrigerators
- charge volume can be approximated
- leakage data from too few manufacturers
- leakage assumed uniform over all refrigerants
- difference in GWP factor 1430 / 5 = 286
- project refrigerators use manufact. leakage data
- no measurement of refrigerant leakage

Blowing Agent SB component

HCFC-141b HFC-245fa HFC-134a Cyclopentane HFO

approximation: all have the same content per refrigerator (at same vol)
all achieve the same efficiency
end up in the atmosphere at some time

➔ Switch Blowing agent GHG reduction only through GWP

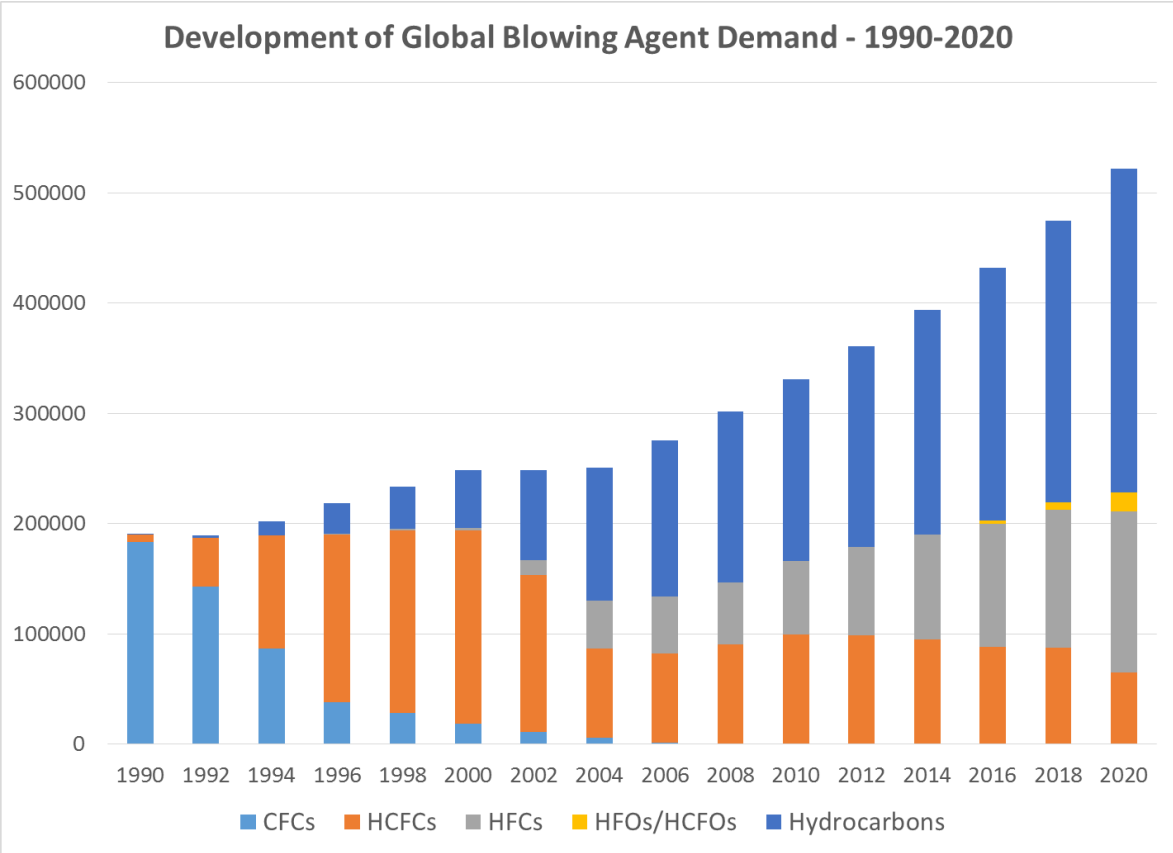


SB switch to Cyclopentane and to HFO
for average appliance sold in previous year
tCO2e / appliance per liter or per kW

Baseline Scenario for Blowing Agents

HCFC are declining

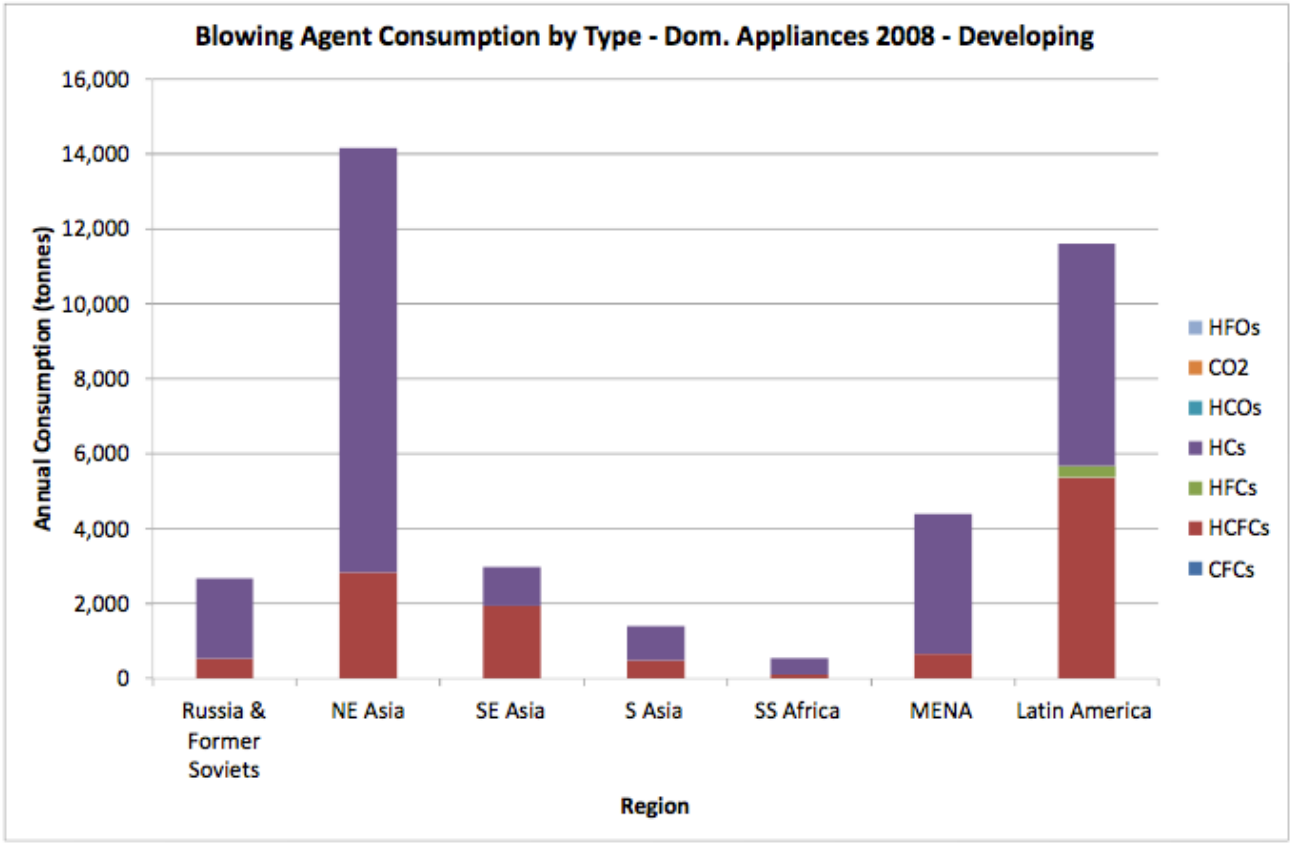
11 Art.5 have HPMP with foam component so far
incremental costs are calculated with Montreal MLF
ineligible companies incur these when up against
phaseout



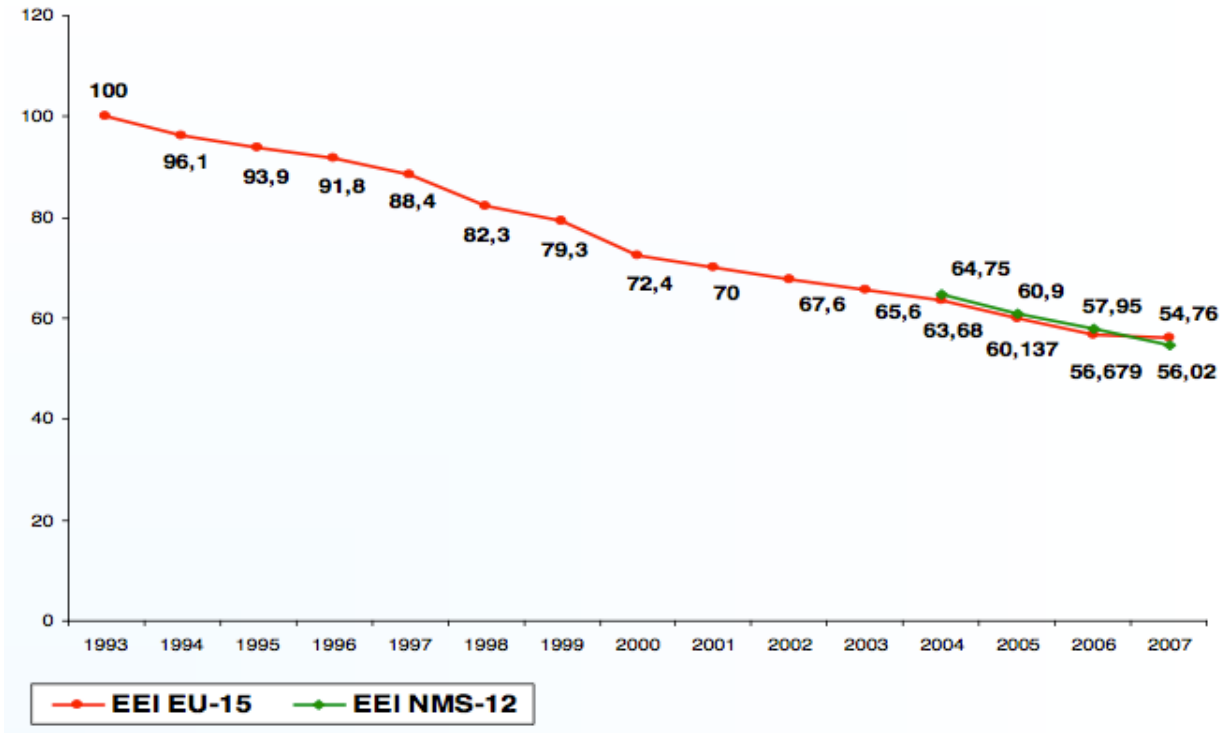
- total vol of foam to estimate with fridge volumes

- share of recovered gases to apportion with foam volume

Regional Variation of Blowing Agents in Appliances



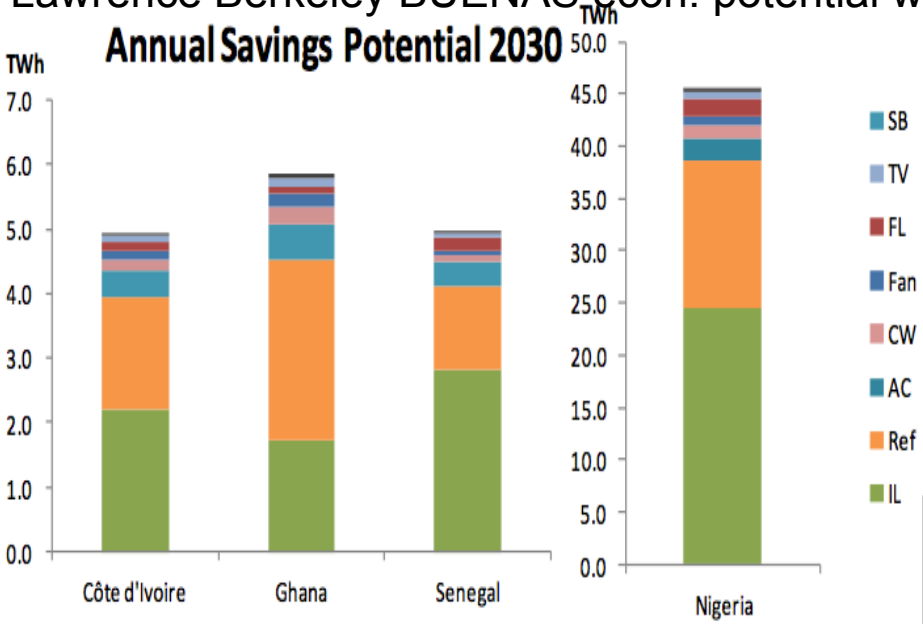
Average Efficiency of all Refrigerators sold in Europe



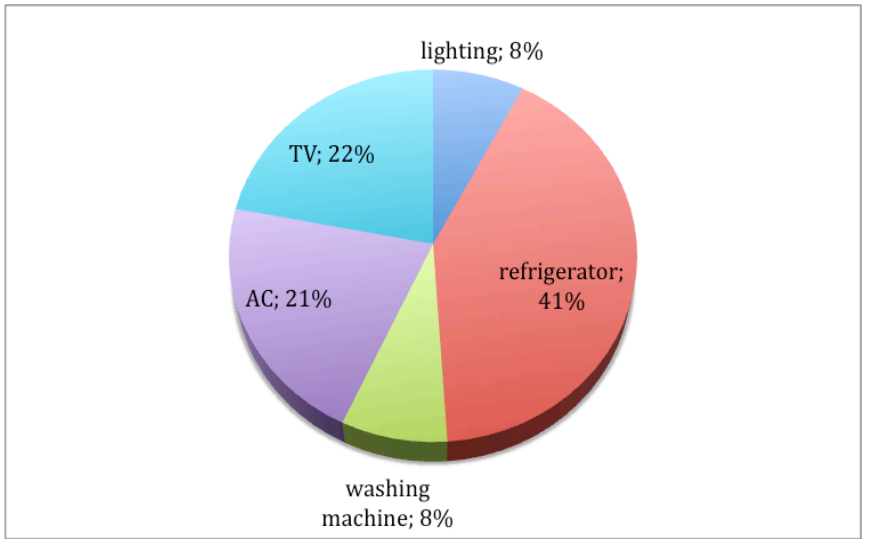
Source: Ecodesign

Examples for Ranking the Efficiency Potential of all Appliances 1 of 2

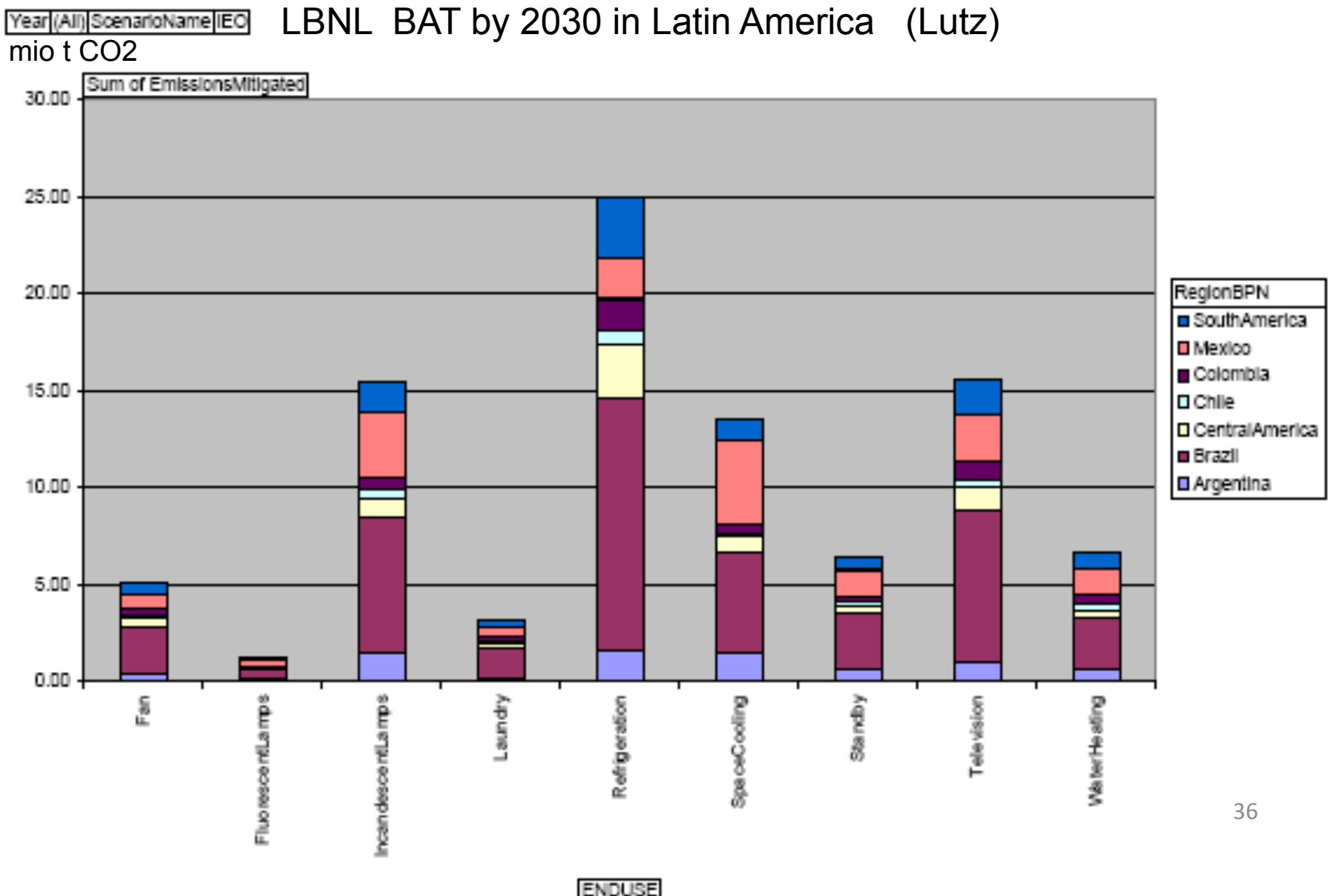
Lawrence Berkeley BUENAS econ. potential with MEPS



Mexico 2012-2030 BAT



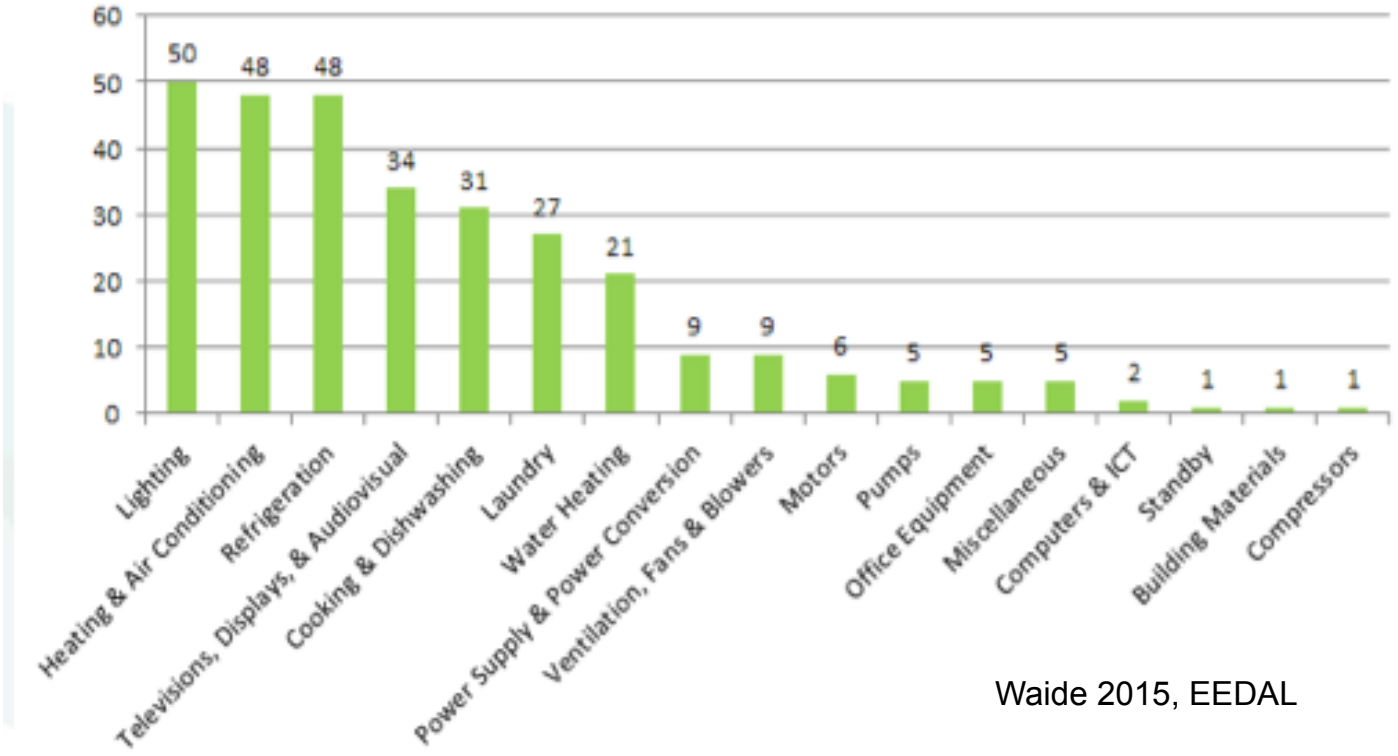
Examples for Ranking Efficiency Potential all Appliances 2 of 2



Lighting, Airconditioner and Refrigerators have most S&L

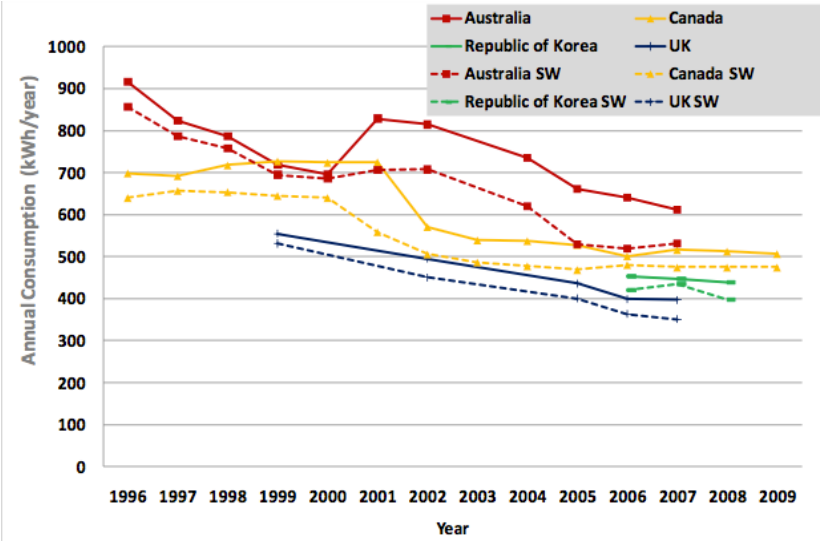
depending on S&L coverage of a country‘s market, benchmark and additionality

Argentina, Australia, Brazil, China, Egypt, Ghana, India, Indonesia, Japan, Jordan, Kenya, Korea, Mexico, Nigeria, Philippines, Russia, South Africa, Tunisia, Turkey, USA



Waide 2015, EEDAL

IEA 4E Mapping 2011 Model Average and Sales-weighted Refrigerator / Freezer

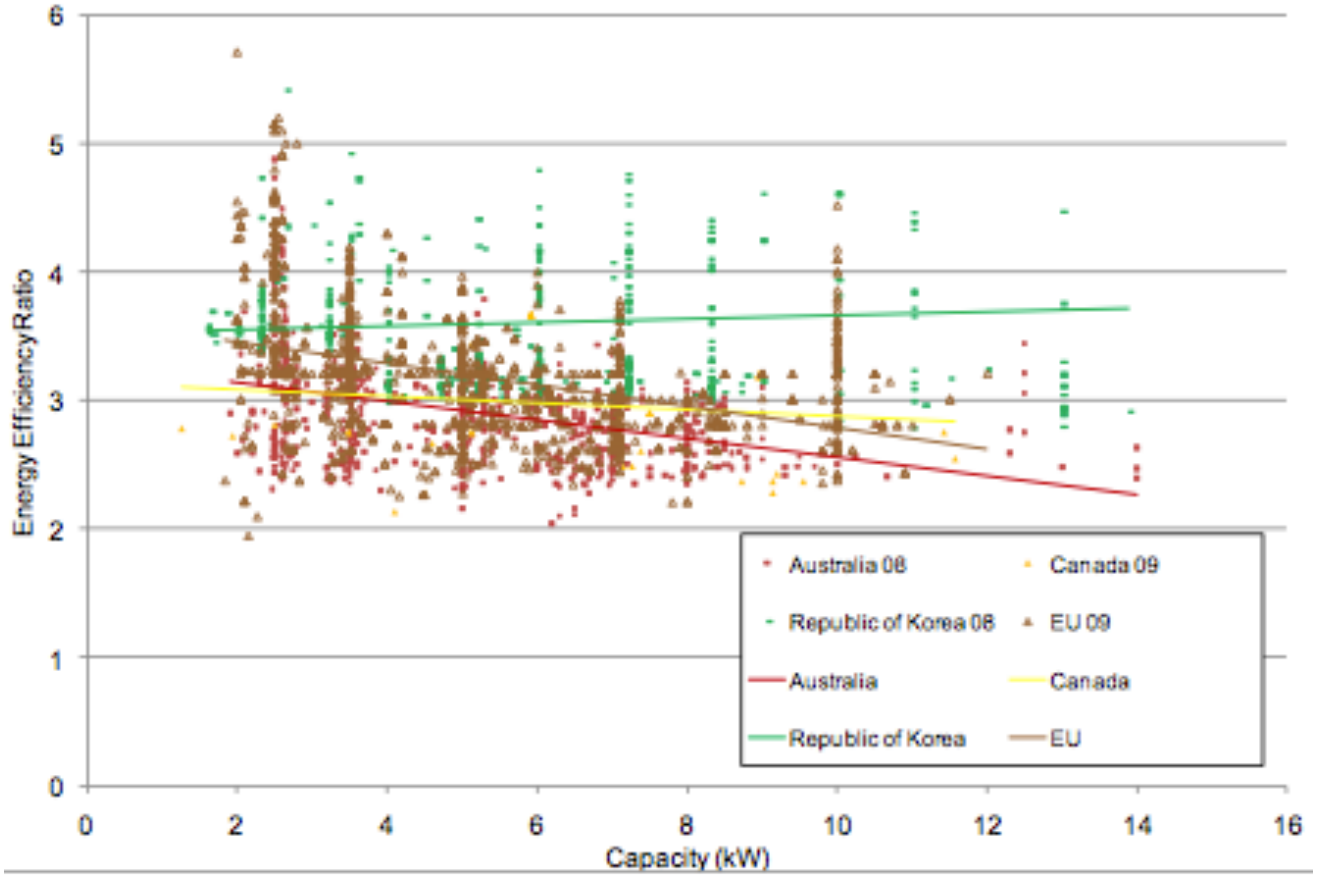


Annual Average Energy Consumption Refrigerators in GfK

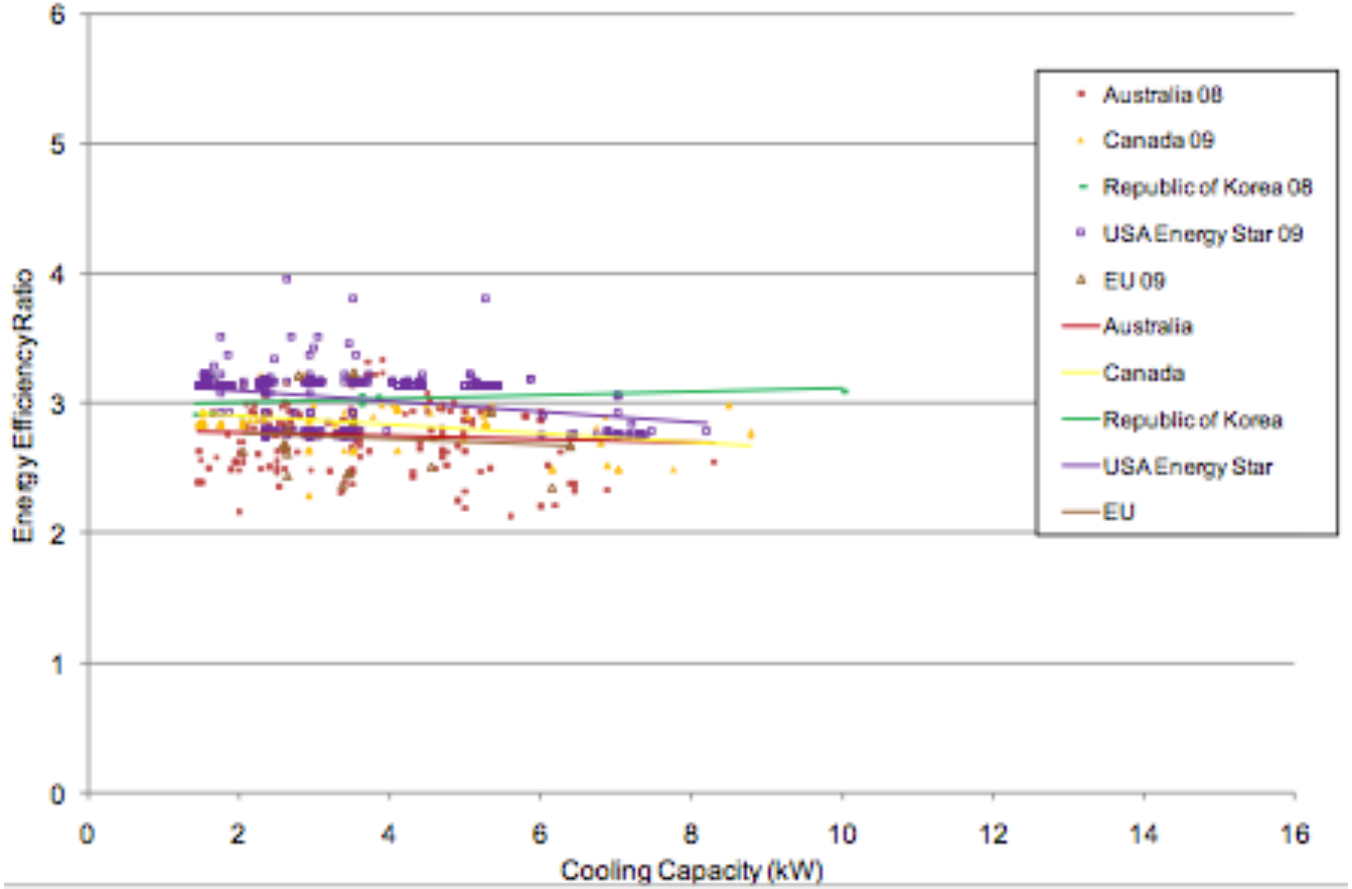
	UAE 2008-2010 303,015 sales			**Turkey 2008-2010**			**UK 2008 - 2010**		
Arithmetic average	415	432	417	478	463	436	284	280	278
Weighted average	373	386	364	503	491	473	266	274	281
GfK model% with energy consumption	82	81	80	31	33	36	92	90	85

Sales weighted average are close to arithmetic averages when most model data include energy consumption data = average model data is not improved with sales numbers in the case of refrigerators (sales vary little with volume)

IEA 4E AC Benchmarking 2011 Split types



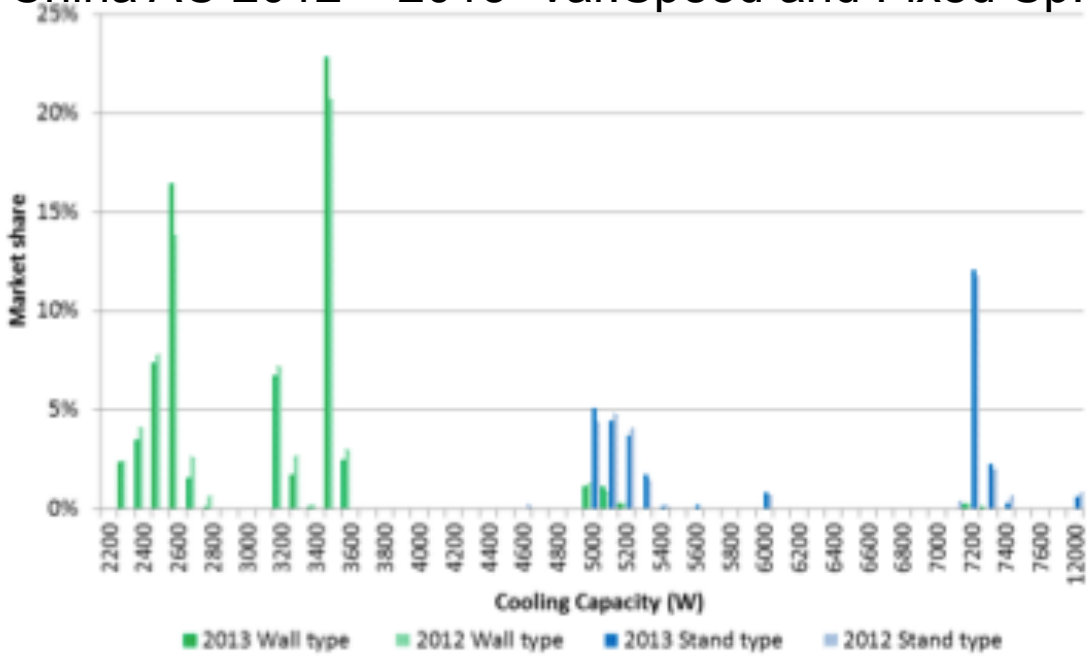
IEA 4E AC Benchmarking 2011 window type



Appliances S&L in Middle Income Countries

	Refrig MEPS Label	AC	WM	lights	TV	Total no. S&L
Argentina	M	M	M	M	M	21
Belarus						
Bosnia						
Brazil	M	M		M/V	M	50
Chile	M	M	M	M	M	28
China	M	M	M	M/V	M	175
Colombia	M	M	M	M	M	30
Ecuador	M	M	M	M	M	14
Grenada						
Honduras						
India	M/V	M/V	V	M/V	M/V	31
Indonesia	V	V	V	M	V	20
Kazakhstan						
Malaysia	M	M/V		M	M/V	20
Mexico	M	V	V	M/V	V	94
Pakistan	V	V		V	V	24
Panama						
Peru	V	V		V		23
Philippines	M	M		M	M	11
South Africa	M	M	M	M	M	30
Surinam						
Thailand	M	V	V	V	V	38
Uruguay	M			M		3
Venezuela	M	M		M		12
Vietnam	M/V	M	M	M/V	M	50

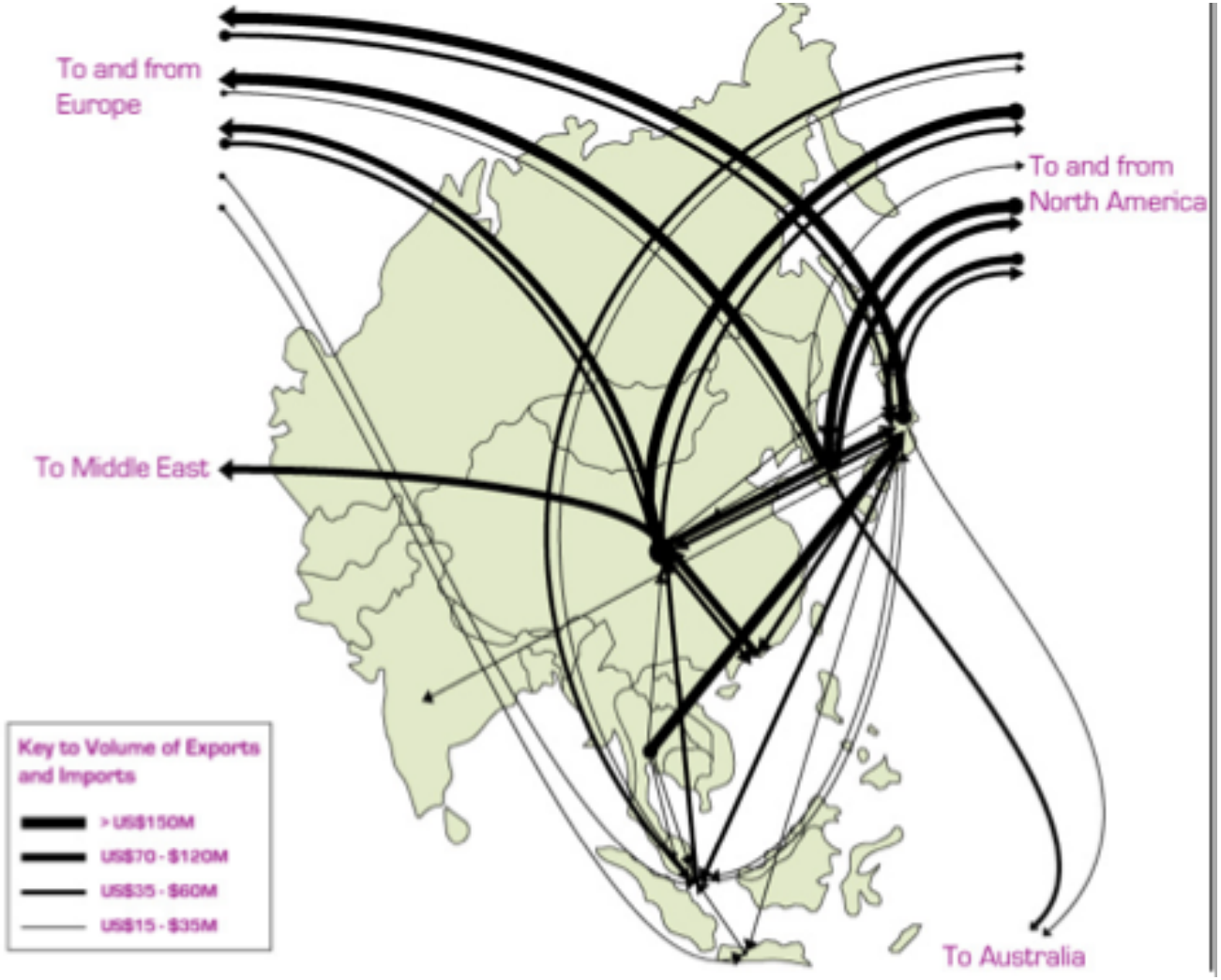
China AC 2012 – 2013 Var.Speed and Fixed Sp.



Product Offer-weighted Shares by Label Class AC China, CNIS

	2007	2008
Grade 1	18	8
Grade 2	14	25
Grade 3	28	23
Grade 4	24	33
Grade 5	16	11

Refrigerator Exports 2010

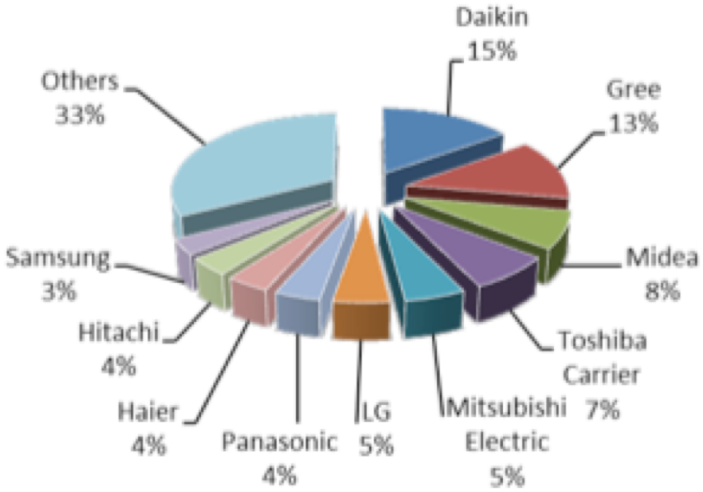


Refrigerator Imports to Africa

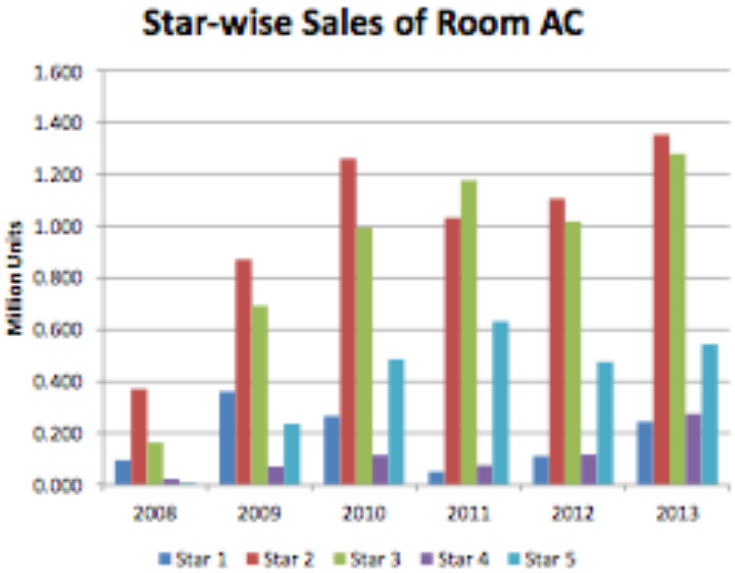
Top Importers of Major Kitchen Appliances	2010-12 avg. p.a. ($m)	% of African imports	% change 2004-06 avg. vs. 2010-12 avg.	Top 3 suppliers
Refrigerators & Freezers				
South Africa	292.3	14.4	37.0	China, Italy, Romania
Nigeria	257.5	12.7	1,882.9	China, India, Australia
Egypt	257.1	12.7	n/a	Thailand, China, Indonesia
Algeria	212.2	10.5	116.5	China, Turkey, Thailand
Morocco	188.8	9.3	107.9	Turkey, Italy, China
Angola	102.4	5.1	191.9	***South Africa***, Brazil, Japan
Libya	76.4	3.8	n/a	Turkey, China, Italy
Tunisia	74.7	3.7	27.3	Italy, France, Turkey
Ghana	43.0	2.1	89.5	China, Britain, US
Kenya	39.3	1.9	206.2	China, Indonesia, Thailand

KPMG 2014

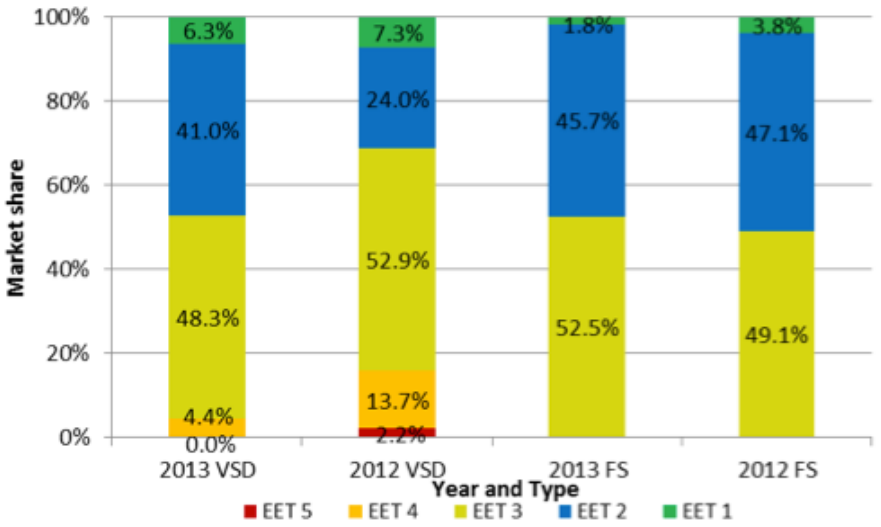
Global AC Market Shares 2014



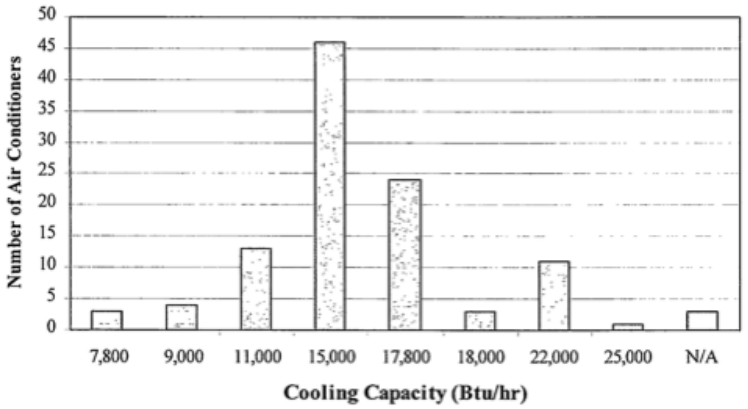
India

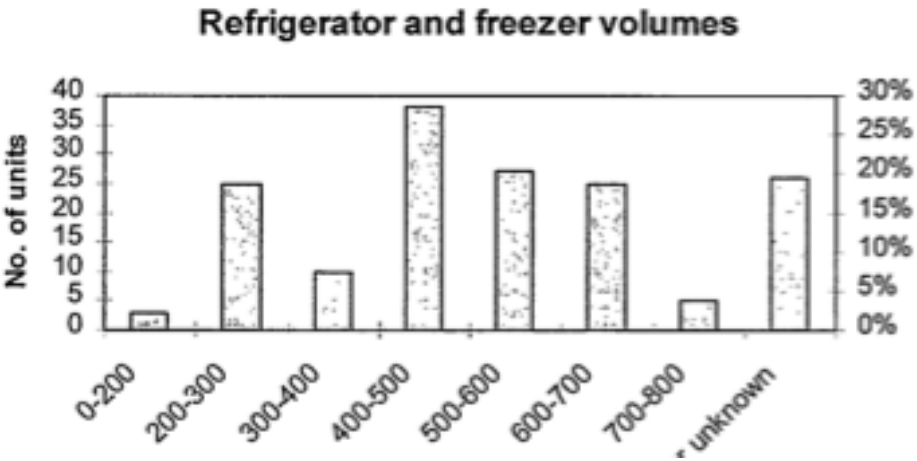


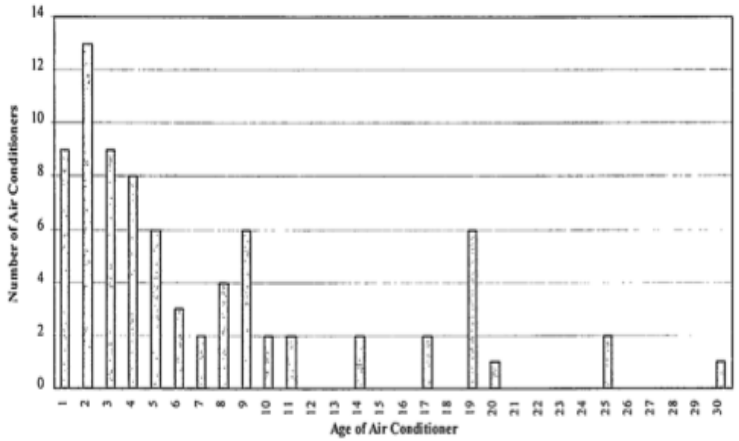
China



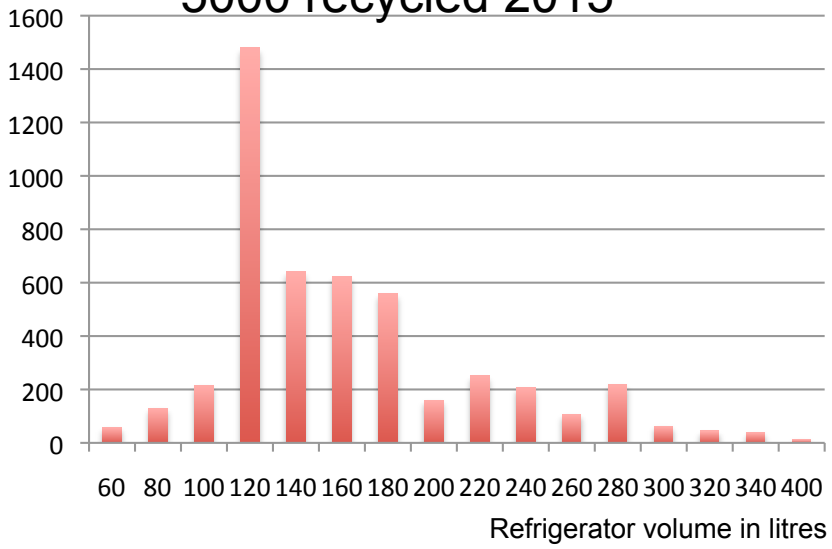
Ghana AC 1999 LBNL







Size distribution in Nat.Rebate Scheme 5000 recycled 2015



Replacements in Ghana 2015

No brands	1098
Brands<15	940
Hotpoint	293
Bosch	193
Zanussi	184
Lec	178
Beko	177
LG	172
Fridgedaire	163
Whirlpool	157
Samsung	121
Candy	98
Electrolux	98
Indesit	84
Kelvinator	62
Ignis	56
Siemens	54
Ocean	52
Philips	52
Daewo	42
AEG	41
Liebherr	42

of 5000 old refrigerators recycled,

2000 have no brands or small ones.

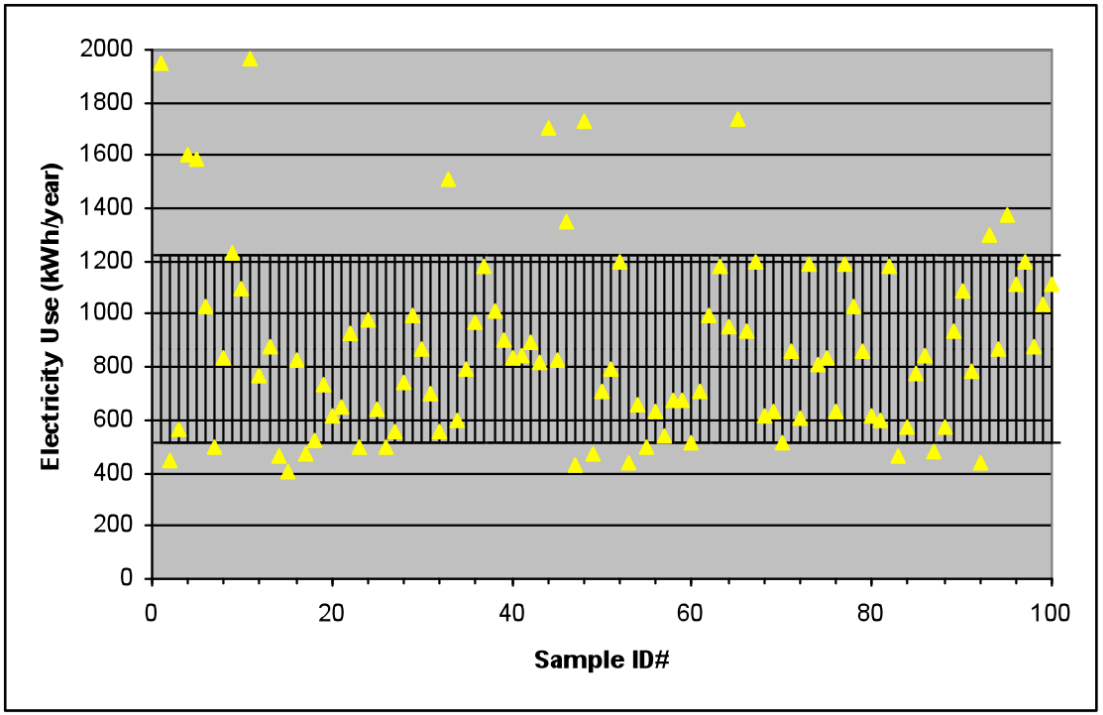
The 12 largest brands are 1920

if the efficiency of these can be established, ≈ 40% of the total but requires noting the model # and check with manufacturer

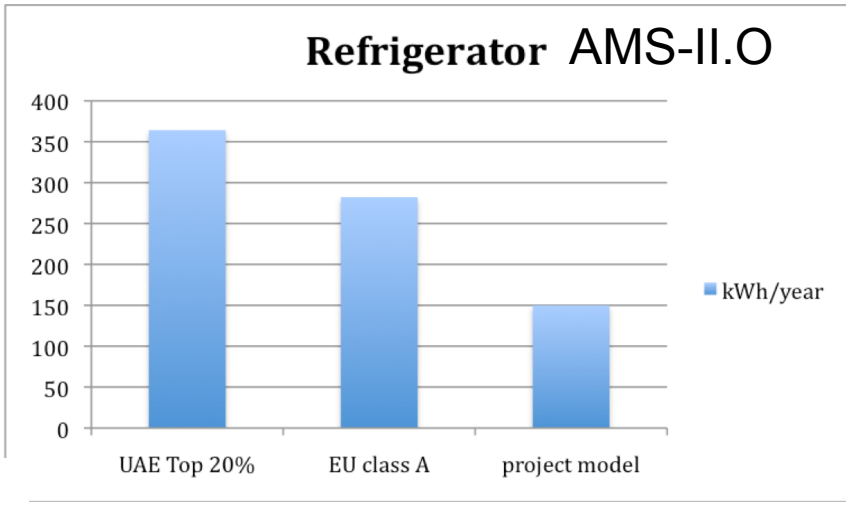
≈ 270 different brands

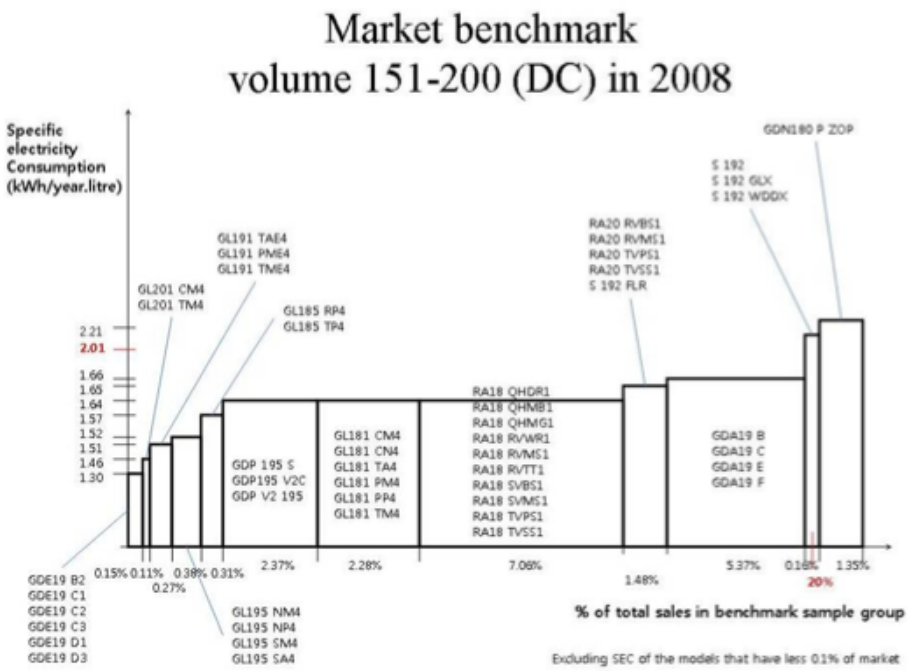
Half of all contain HFC-134a
25% isobutane
25% CFC-12

Brazil Random Sample 100 Old Refrigerators 2008 from five Electric Utilities across Brazil



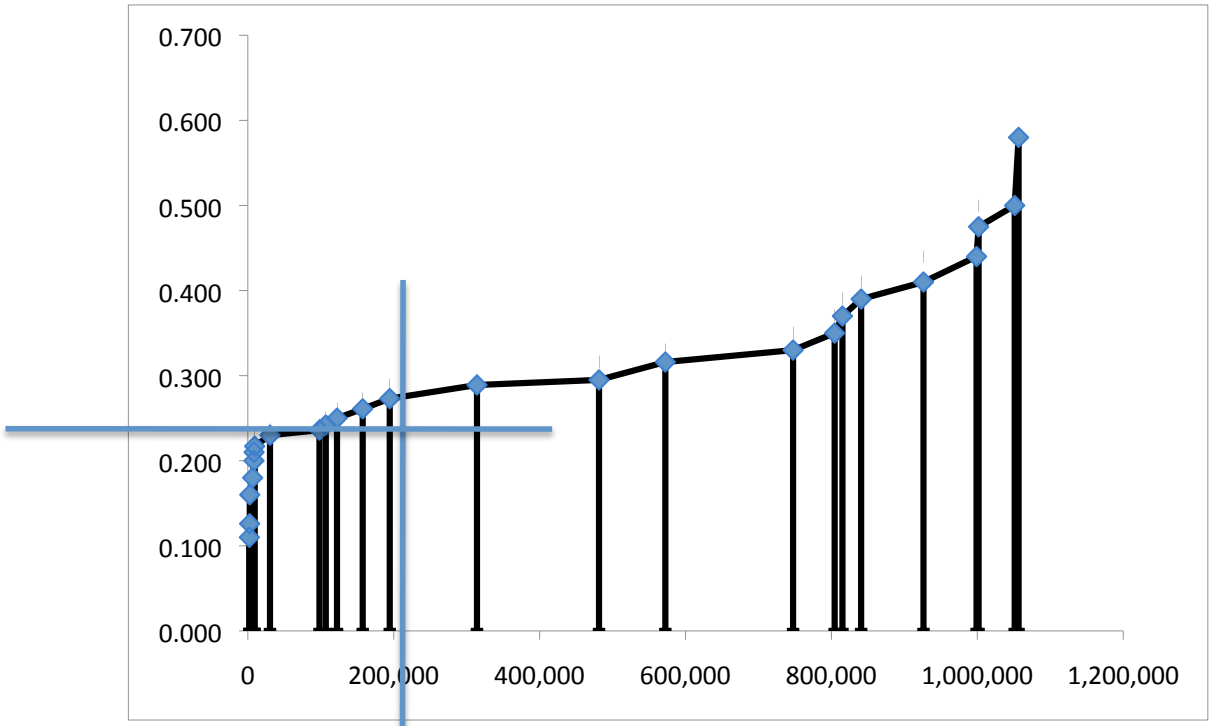
Source: http://cdm.unfccc.int/UserManagement/FileStorage/YK0DG9T0T0RHMCK69NDYKCG3ZBWX2L


Refrigerator AMS-II.O
400
350
300
250
200
150
100
50
0
UAE Top 20%
EU class A
project model
kWh/year


Market benchmark
volume 151-200 (DC) in 2008
Specific electricity Consumption (kWh/year.litre)
2.21
2.01
1.66
1.65
1.64
1.57
1.52
1.51
1.46
1.30
GDE19 B2
GDE19 C1
GDE19 C2
GDE19 C3
GDE19 D1
GDE19 D3
GL201 CM4
GL201 TM4
GL191 TAE4
GL191 PME4
GL191 TME4
GL185 RP4
GL185 TP4
GL195 NM4
GL195 NP4
GL195 SM4
GL195 SA4
GDP 195 S
GDP195 V2C
GDP V2 195
GL181 CM4
GL181 CN4
GL181 TA4
GL181 PM4
GL181 PP4
GL181 TM4
RA18 QHDR1
RA18 QHMB1
RA18 QHMG1
RA18 RVWR1
RA18 RVMS1
RA18 RVTT1
RA18 SVBS1
RA18 SVMS1
RA18 TVPS1
RA18 TVSS1
RA20 RVBS1
RA20 RVMS1
RA20 TVPS1
RA20 TVSS1
S 192 FLR
S 192
S 192 GLX
S 192 WDGX
GDN180 P ZOP
GDA19 B
GDA19 C
GDA19 E
GDA19 F
0.15%
0.11%
0.27%
0.38%
0.31%
2.37%
2.28%
7.06%
1.48%
5.37%
0.16%
1.35%
20%
% of total sales in benchmark sample group
Excluding SEC of the models that have less 0.1% of market

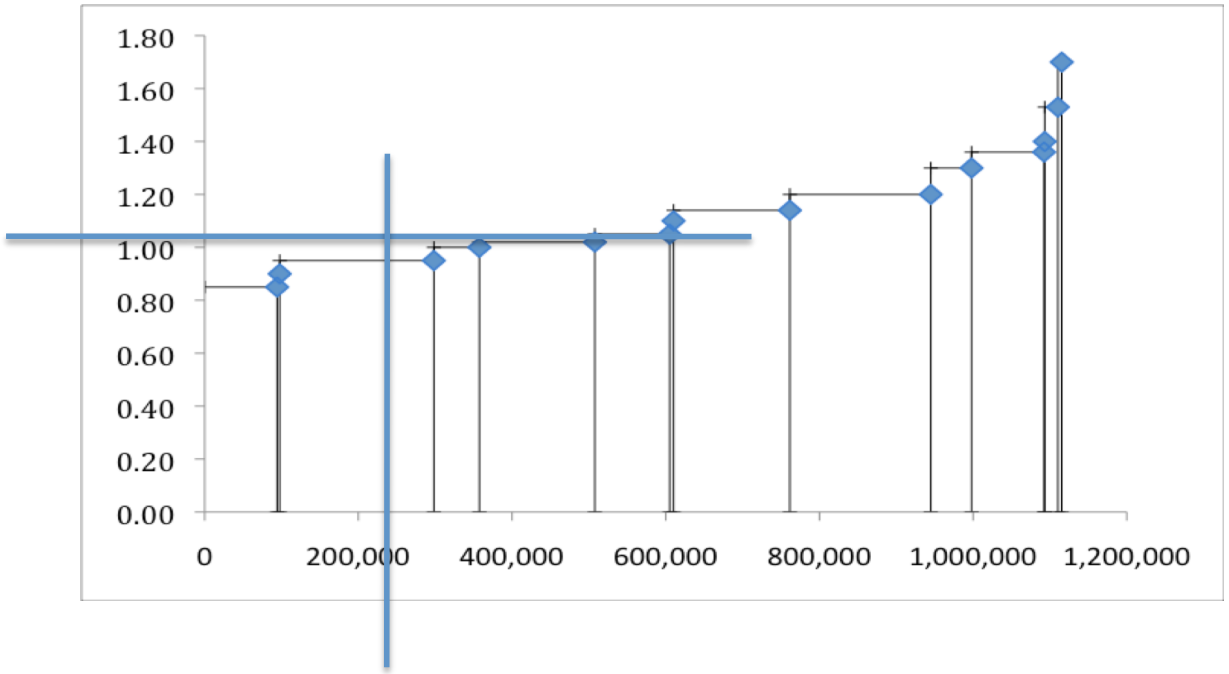
Benchmarks

Refrigerators sold in Turkey in 2010, kWh/100l GfK data



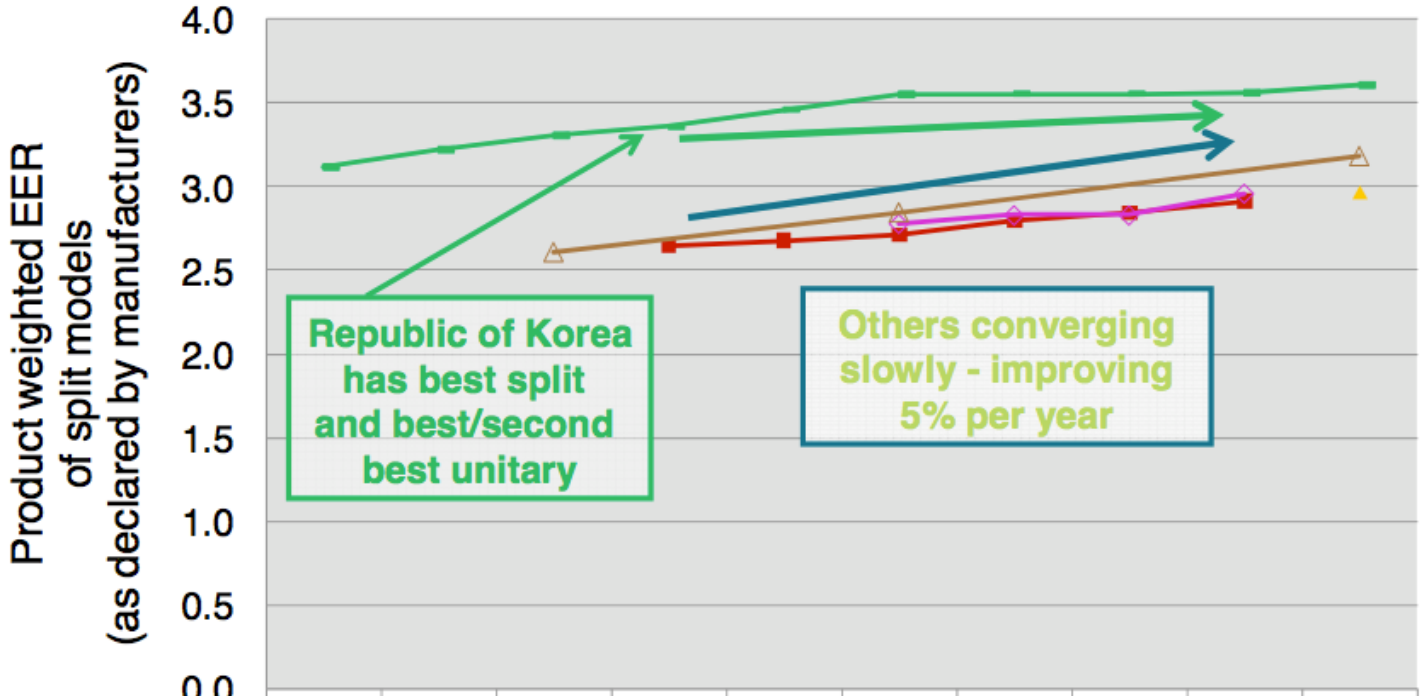
20% of sales define requires total sales# and efficiencies

Washing Machines Sold in Turkey in 2010



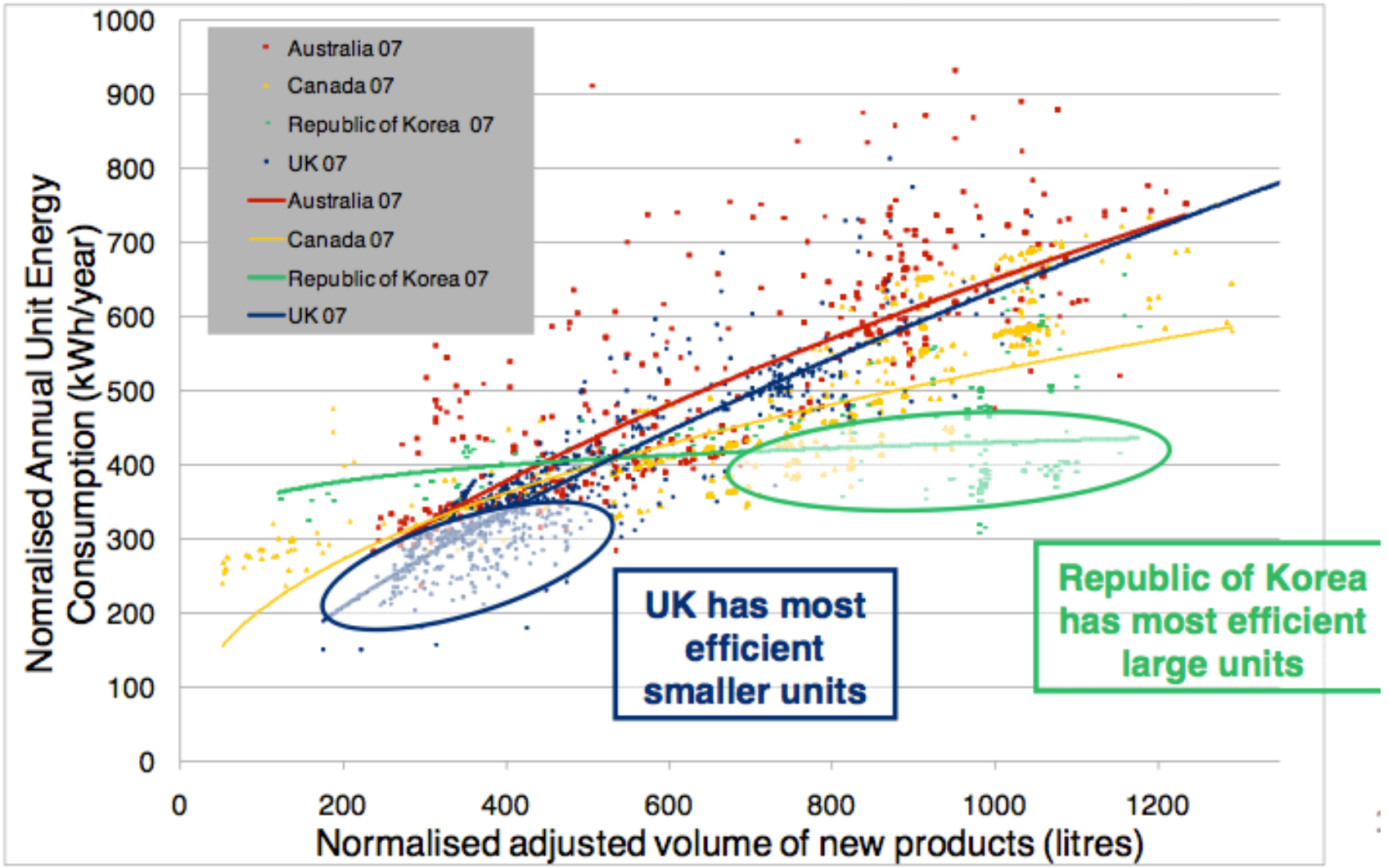
20% of sales
is lower efficiency than 20% from efficiency

Airconditioners EER Trends by IEA 4E Benchmarking

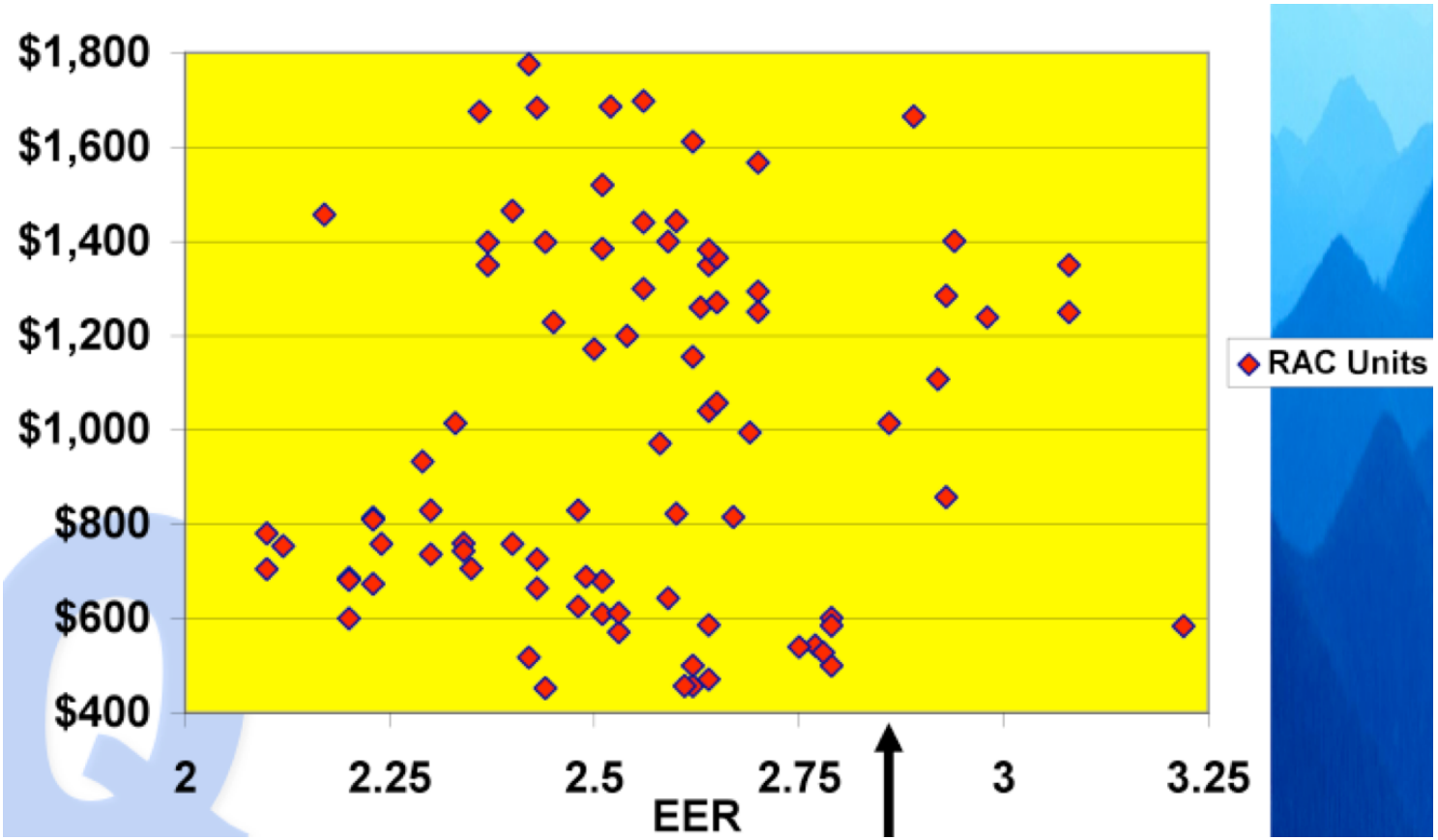


	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Australia				2.65	2.68	2.71	2.80	2.84	2.91	
Canada										2.97
Republic of Korea	3.11	3.22	3.31	3.36	3.46	3.55	3.55	3.55	3.56	3.61
China						2.78	2.83	2.83	2.96	
EU			2.61			2.84				3.18

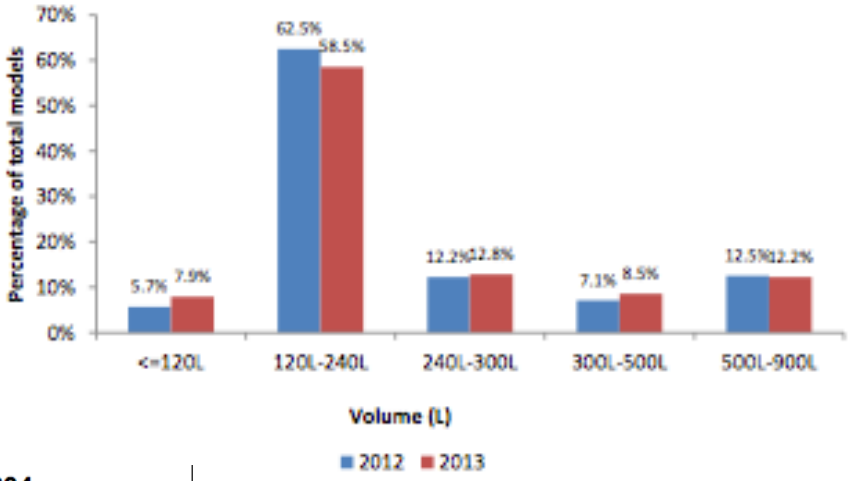
Refrigerator Efficiency Variations IEA 4E Benchmarking 2011

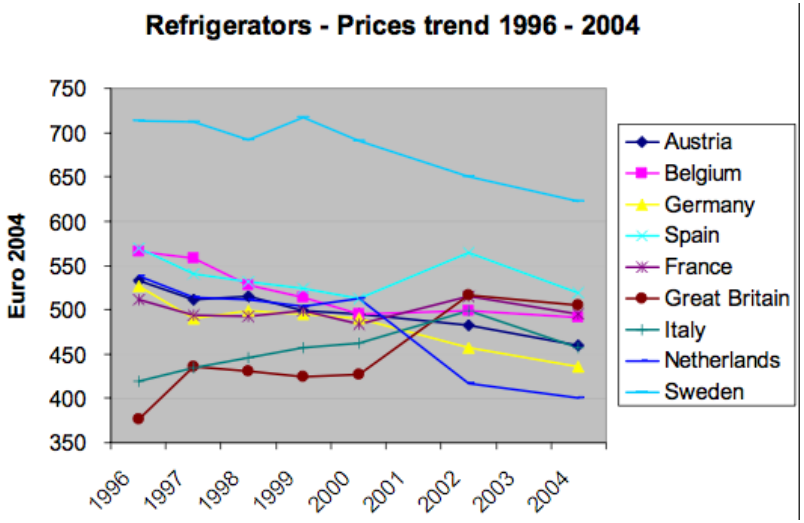


Ghana AC models from Quality Tonnes

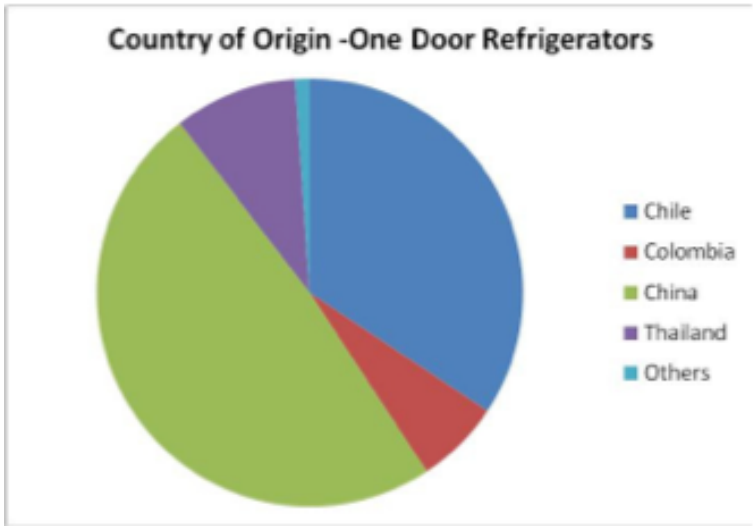


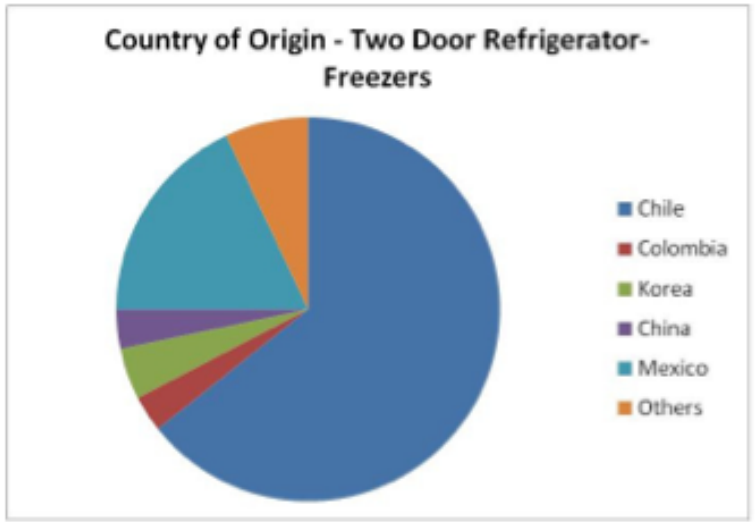
China Refrigerators 2013-12 Sizes Unadjusted





Total Sales in Chile in 2009





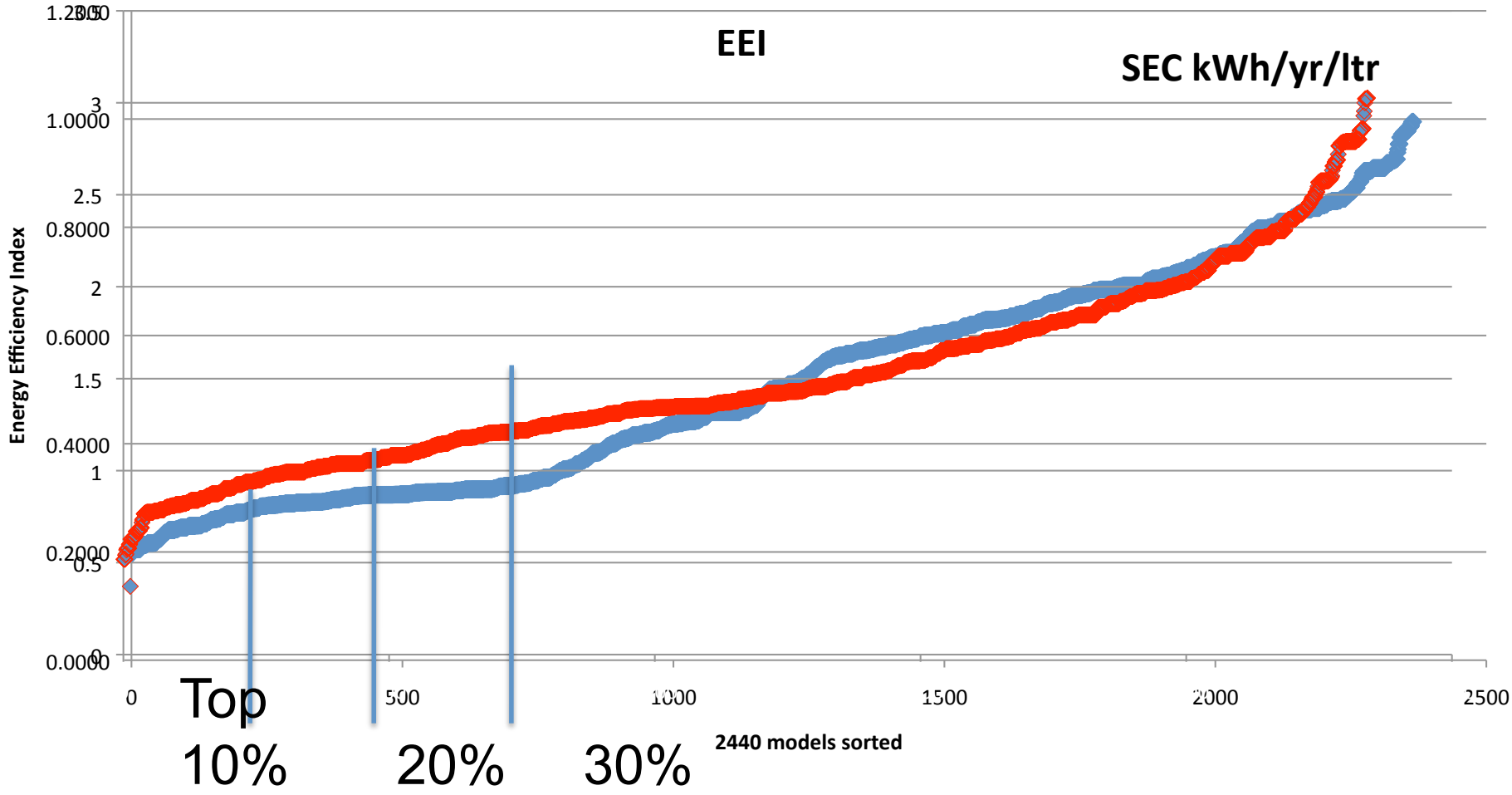
2.440 models recorded in shop visits across Ghana in 2015

Region	Town	Brand	Model_Numbe	CC	V_{fresh}L	V_{frozen}L	_kWh/a	l_Volur	_rat	efrigeran	uanti
Ashant	Agogo	Iceking	I-193R	T	84	9	182.5	93	3	R600a	1
Ashant	Agogo	Iceking	I-212	T	0	203	350.4	203	2	R600a	1
Ashant	EJURA	AVEO	AV-115	ST	67	29	164	96	2	R600a	1
Ashant	EJURA	BEKO	RDE6192NC	ST	125	45	289	170	2	R600a	1
Ashant	EJURA	BENATONE	FE-230D	ST	179	51	277.4	230	1	R134a	1
Ashant	EJURA	BRUHM	BCF-SD320	ST	0	320	438	320	1	R134a	1
Ashant	EJURA	BRUHM	BRS-G120S	ST	97	0	123	97	4	R134a	1
Ashant	EJURA	DIYA	DF-10	ST	45	5	136	50	2	R134a	1
Ashant	EJURA	EAST POINT	EPRF200S	ST	93	45	358	138	3	R134a	1
Ashant	EJURA	AIR THERMOCOC	HRF-350NW	ST	241	80	416	321	2	R134a	1
Ashant	EJURA	LEGACY	LGYF-138	ST	93	45	339	138	2	R134a	1
Ashant	EJURA	MICHACHI	MIK-178	ST	0	178	321	178	1	R134a	1
Ashant	EJURA	PRESTIGE	PR-15D	ST	65	25	187	90	2	R134a	1
Ashant	EJURA	prolux	PRX-250-GE	ST	134	75	292	209	3	R600a	1
Ashant	EJURA	SAMSUNG	RT26FARAWDDA	ST	150	53	220	203	4	R600a	1
Ashant	Obuasi	AKAI	RF016A-48	ST	46	0	99.64	46	4	R600a	1
Ashant	Obuasi	AIR THERMOCOC	HRF-250NW	ST	122	45	361	167	2	R134a	1
Ashant	Obuasi	AIR THERMOCOC	HRF-350NW	ST	241	70	416	311	2	R134a	1
Ashant	Obuasi	AIR THERMOCOC	HTF-429GAA	ST	0	429	523	429	2	R600a	1
Ashant	Obuasi	Kepas	KFG-112	ST	81	9	170	90	2	R134a	2
Ashant	Obuasi	LG	GL-B312VML	ST	203	65	462	268	2	R134a	1
Ashant	Obuasi	SAMSUNG	RR21H1147DA	ST	164	18	195	182	2	R134a	1
Ashant	Obuasi	SAMSUNG	RT26HAR2DDA	ST	150	53	220	203	4	R600a	1
Ashant	Obuasi	SAMSUNG	RT31FAREDDA	ST	202	53	253	255	3	R600a	1
Ashant	Obuasi	SAMSUNG	ZR26FARAEWW	ST	0	253	381	253	1	R134a	1
Ashant	Obuasi	SAMSUNG	ZR41FARAEWW	ST	0	395	503	395	1	R134a	1
Ashant	Obuasi	SHARP	ST-5172KN-SL	ST	115	28.5	400	143.5	1	R134a	1
Ashant	Obuasi	Tamashi	TCF-SD168	ST	0	142	255	142	1	R134a	1
Ashant	Obuasi	Tamashi	TCF-SD188	ST	0	180	318	180	1	R134a	1
Brong A	Atebubu	Akai	NCF-158	T	0	158	393	158	2	R134a	1
Brong A	Atebubu	Aveo	AV-115	ST	67	29	164	96	2	R600a	2

5,000 recycled fridges in 2015 at the site in Accra

TEN. COMPRESSORS		DATE	NAME OF COMPANY	BRAND	TRACKING NO.:					VOLUME (litres)	EMARI	GAS TYPE	GAS WEIGHT (g		
													R12	600a	134a
1	1	15.Jan	Tradeworks	Fridgemaste	02	GR	02	070113	114	80		600a		70	
2	1	15.Jan	Tradeworks	Exquisit	02	GR	02	110113	119	160		600a			
3	1	15.Jan	Tradeworks	Iberna	02	GR	02	080113	117	240		R 12	70		
4	1	15.Jan	Tradeworks	Hoover	02	GR	02	080113	115	340		R12			
5	1	15.Jan	Tradeworks	Bosch	02	GR	05	081212	46	180	Freeze	134a			
6	1	15.Jan	Tradeworks	**No brand**	02	GR	05	101212	48	180		600a		70	
7	1	15.Jan	Tradeworks	Bosch	02	GR	05	271212	55	300		R 12			
8	1	15.Jan	Tradeworks	Whirlpool	02	GR	05	201212	53	100	Freeze	600a		90	
9	1	15.Jan	Tradeworks	Fridgidaire	02	GR	02	080113	116	320		600a		70	
10	1	15.Jan	Tradeworks	Philips	02	GR	05	111212	49	280		134a			
11	1	15.Jan	Tradeworks	Electrolux	02	GR	02	020113	113	350		600a		90	
12	1	15.Jan	Tradeworks	Hotpoint	02	GR	03	020113	125	300		134a			
13	1	15.Jan	Tradeworks	Ignis	02	GR	03	311212	121	170	Freeze	134a			
14	1	15.Jan	Tradeworks	Wilson	02	GR	05	151212	51	260		600a		0	
15	1	15.Jan	Tradeworks	AEG	02	GR	05	191212	52	140		R 12	100		
16	1	15.Jan	Tradeworks	Prestige	02	GR	03	311212	122	140		600a		90	
17	1	15.Jan	Tradeworks	Philips	02	GR	03	271212	110	350		600a		0	
18	1	15.Jan	Tradeworks	Fridgemaste	02	GR	02	281212	110	100		134a			
19	1	15.Jan	Tradeworks	Rex	02	GR	03	291212	118	320		R 12			
20	1	15.Jan	Tradeworks	Ariston	02	GR	02	271212	107	240		600a		90	
21	1	15.Jan	Tradeworks	Daewoo	02	GR	02	241212	103	140		134a			
22	1	15.Jan	Tradeworks	Vendomatic	02	GR	03	281212	116	160		600a		60	
23	1	15.Jan	Tradeworks	Tricity	02	GR	03	281212	113	140		R 12	60		
24	1	15.Jan	Tradeworks	Whirlpool	02	GR	05	081212	47	180		134a			
25	1	15.Jan	Tradeworks	Vestfrost	02	GR	03	281212	113	360	Freeze	134a			
26	1	15.Jan	Tradeworks	Goldstar	02	GR	01	221212	72	140		134a			
27	1	15.Jan	Tradeworks	Fridgidaire	02	GR	05	151212	50	140		134a			
28	1	15.Jan	Tradeworks	Ecoline	02	GR	02	131212	91	400		R 12	90		
29	1	15.Jan	Tradeworks	LG	02	GR	02	311212	112	140		134a			

2440 models in shops ranked from most to least efficient



New Sales SB thresholds

Top 40% EEI 42

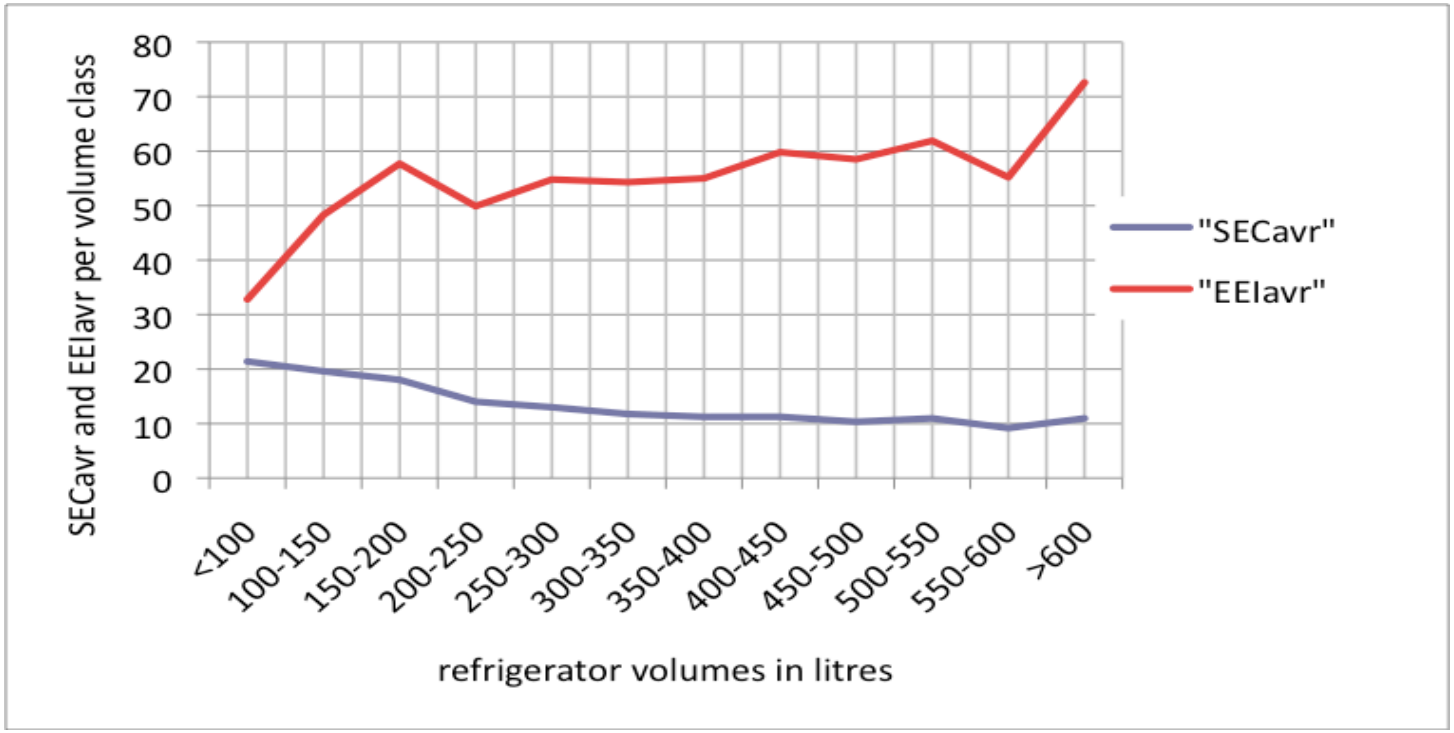
Top 30% EEI 32.6

Top 20% EEI 30.6

Top 10% EEI 28

Thresholds for Volume Classes among 2440 models

Volume	<100	100-150	150-200	200-250	250-300	300-350	350-400	400-450	450-500	500-550	550-600	>600
No. models	265	313	415	459	272	232	133	101	44	125	21	40
AECavr kWh/yr	163	244	320	305	350	369	420	470	488	565	530	734
SECavr kWh/yr/ltr	2.14	1.96	1.804	1.402	1.30	1.176	1.124	1.125	1.034	1.096	0.918	1.096
EEIavr	32.8	48.3	57.7	49.9	54.8	54.3	55.0	59.8	58.5	61.9	55.2	72.6



New Sales SB

Top 20% thresholds product-weighted not sales-weighted

three EEI thresholds

< 100 ltr	EEI 22
100-550 ltr	EEI 30.6
>550 ltr	EEI 42

$$BE_y = EF_{grid} * n_{p,i,y} * \frac{EEI_{avr,y}}{100} * SAE_{avr,p}$$

six SEC thresholds

<100 ltr	1.70 kWh/yr/ltr
100-200	1.48
200-300	
300-400	0.92
400-500	0.88
>500 ltr	0.84

$$BE_y = EF_{grid} * n_{p,i,y} * V_{avr,p} * SEC_{avr,y}$$

Additionality on last year‘s purchase decisions Top 20% ?
Baseline on average efficiency Top 40% ?

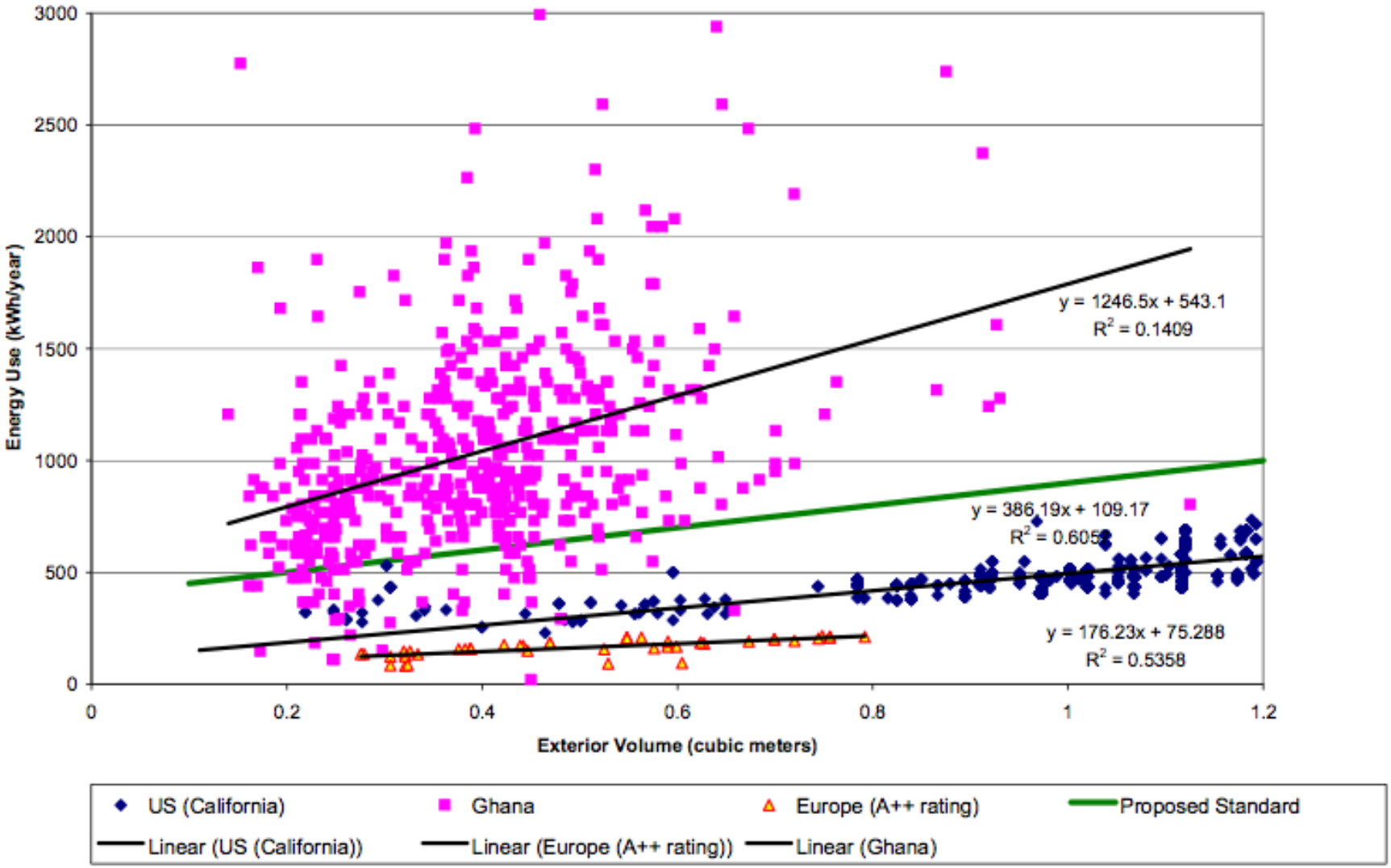
Parameter with broad distribution is better for SB

SEC (kWh/yr/ltr)	<0.8	0.8 - 1.4	1.4 - 1.7	1.7 - 2.0	2.0 - 2.3	2.3 - 2.6	2.6 - 3
No. models	94	460	451	350	193	105	63
EEI (dim-less)	<0.3	0.3-0.4	0.4-0.5	0.5-0.6	0.6-0.7	0.7-0.8	0.8-1.1
No. models	410	490	290	294	401	229	291

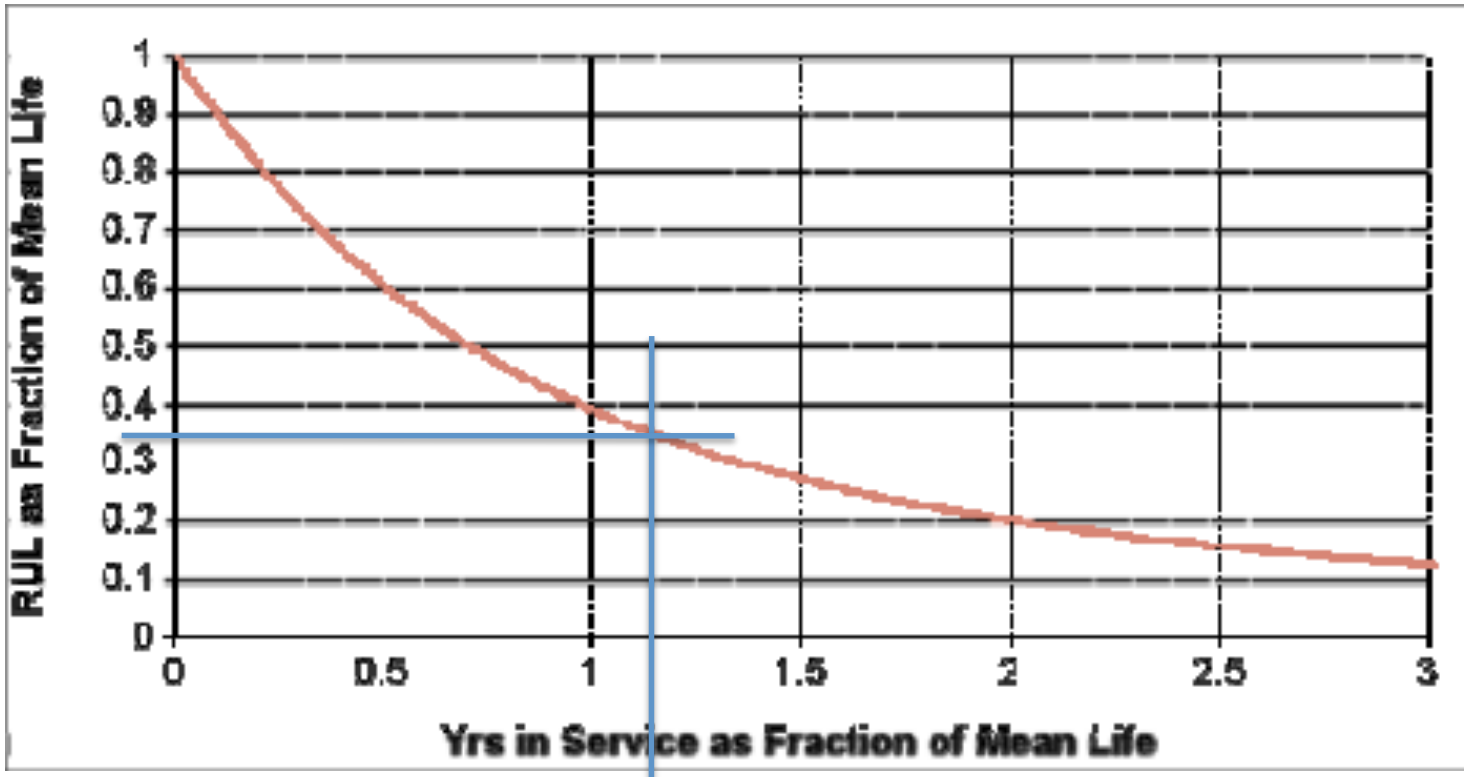
	Number of models	Average SEC	Average EEIx100	Average volume of models
1 Star	575	1.846	67.6	269.9
2 Star	713	1.612	57.8	236.9
3 Star	768	1.394	42.6	225.8
4 Star	310	1.160	34.7	262.2
5 Star	21	1.054	32.3	292.4

Replacement SB: last sample measured in situ 1000 HH

CSIR 2008 for Nkrumah Uni and LBNL



Welch and Rogers 2010 Estimating the Remaining Useful Life of Residential Appliances, ACEEE summer study (Navigant Consulting Inc.)



16 yrs / 14 yrs = 1.14

16 yr average age of functioning fridges replaced

RUL = 0.33 x 14 = 4.6 yrs

Results from Ghana Replacement Program are not available

Replacement Baseline

$$BE = EF_{grid} * n_{P,i,y} * V_{avr} * SEC_{Bl} * RUL_{avr} \div 1000$$

1000 HH sample results:

AECavr 1.164 kWh/yr / Vavr 203 ltr = 5.734 kWh/yr/ltr

BE = 0.33 tCO2/MWh * $n_{P,i,y}$ * V_{avr} * 5.734 kWh/ltr * 4.6 yr / 1000

applies to the Ghana Replacement Program because the 1000 HH was stratified and the Replacement Program is open for all

with SEC open to varied households, similar with EEI

when the sample is selective and the Replacement Program simila be allowed without any restriction ?

RUL and SEC/EEI option for ex post ? more replacement program encourages targeting of households or refrigerator types

New Sales Baseline	<100 ltr EEI 22 100-550 EEI 30.6 >550 EEI 42	<100 1.7 kWh/yr/lts 100-200 1.48 200-300 1.08 300-400 0.92 400-500 0.88 > 500 0.84
Replacement Baseline		5.734 kWh/yr/ltr 4.6 yrs RUL
Refrigerant Baseline	0.345 kgCO2e/ltr	

Refrigerant Baseline

$$SREF_y = \frac{\sum^{j}\left(REF_{i,j,y} * n_{i,y} * GW\ P_j\right)}{\sum n\ * V_{avr}}$$

For HFC-134a: charge [gram] = 0.2268 x volume [liter] + 45.96

For Iso-butane: charge [gram] = 0.0775 x volume [liter] + 31.27

$$\frac{128{,}327 \text{ x } (1000/2440) \text{ x } 0.0509 \text{ x } 3 \ + \ 128{,}327 \text{ x } (1440/2440) \text{ x } 0.10014 \text{ x } 1430}{128{,}327 \quad \text{x} \quad 245 \text{ liter}}$$

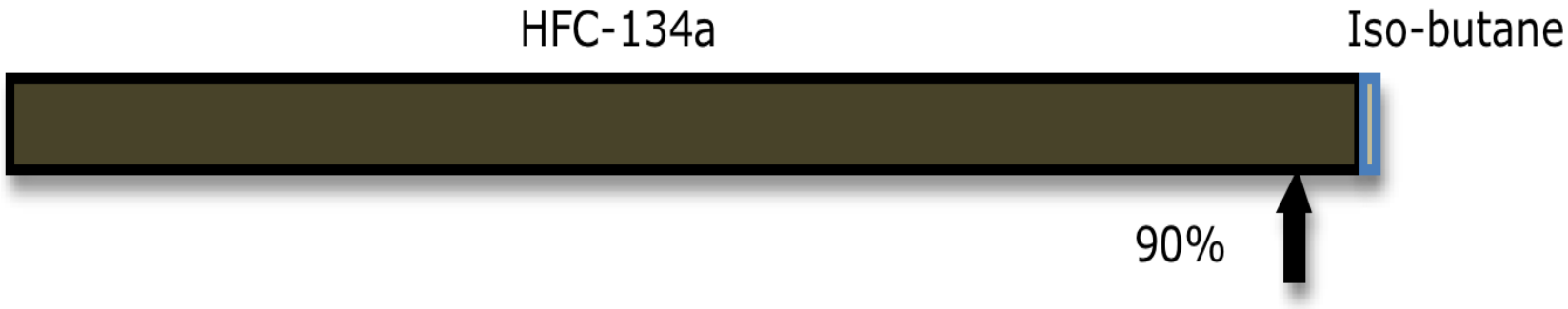
$SREF_y$ = 0.345 $kgCO_2e$/liter refrigerator volume

Additionality: each one retailer or importer to eliminate HFC-134a completely

can apply SREF on sales in the preceding year, because his supply decision has no impact on household

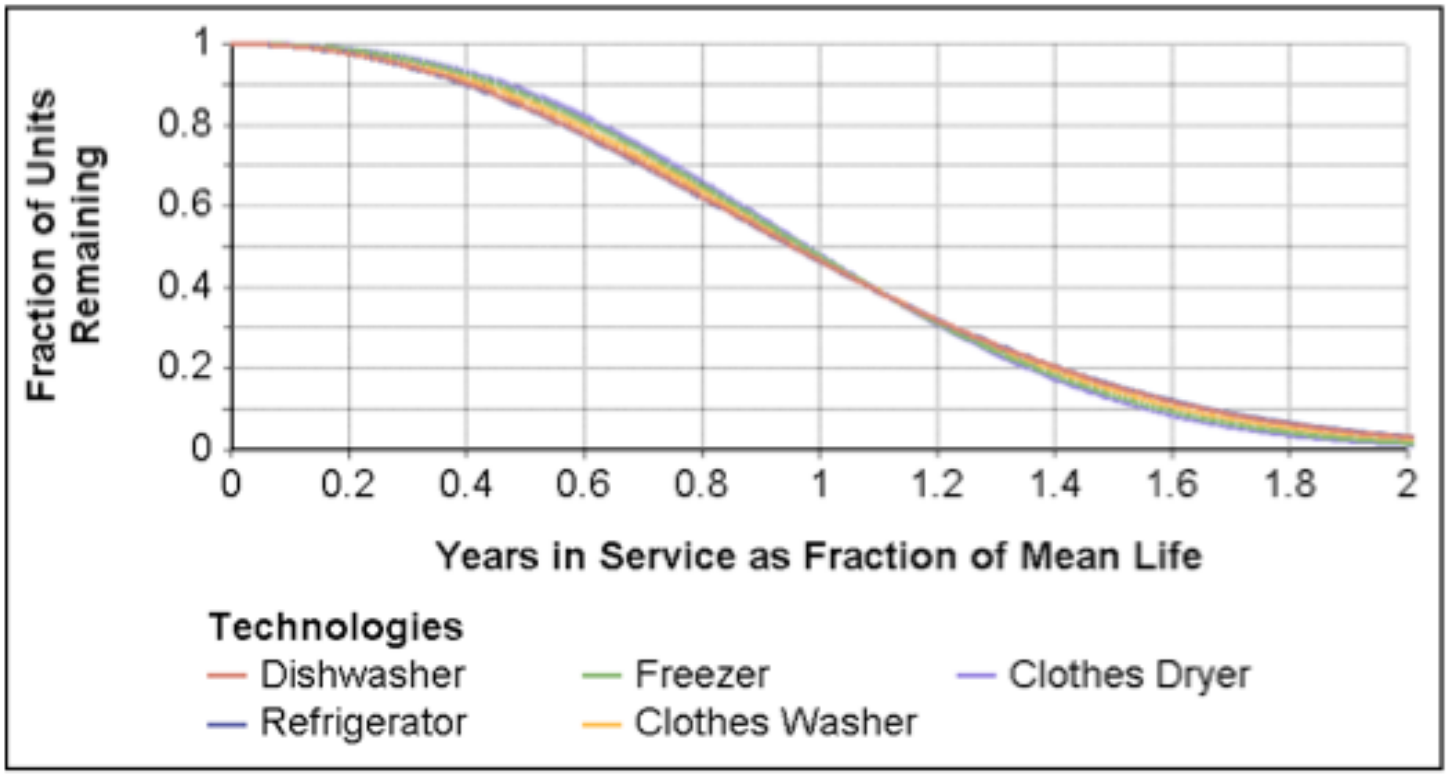
Refrigerant bar chart:

all HFC-134a refrigerators in 2015: 10.845 t CO_2e
all Iso-butane refrigerators 2015: 8 t CO_2e

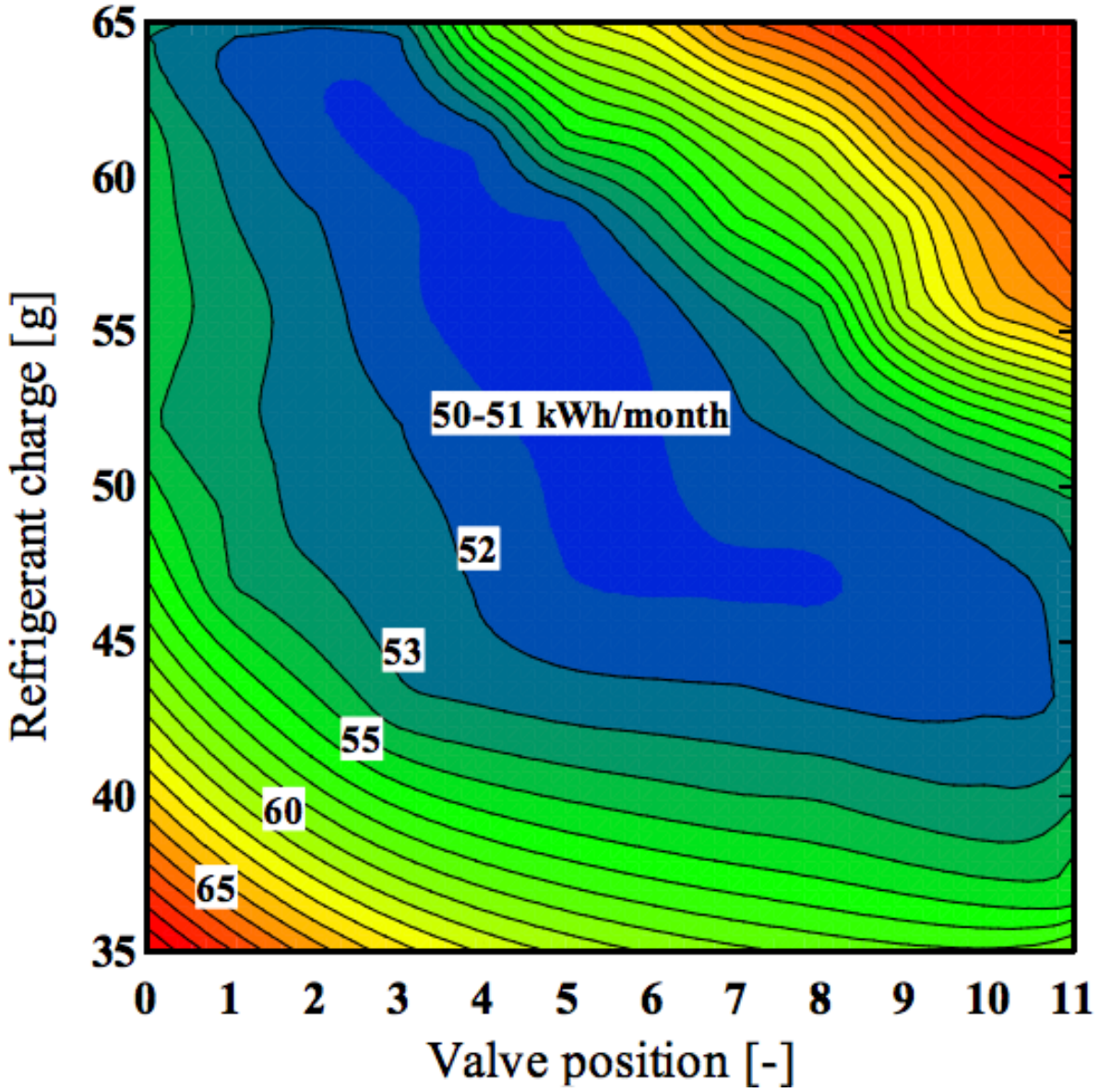


Refrigerant SB to anticipate HFC Phase-out Plan of Ghana Ozo

Figure 5. Normalized Weibull Curve Fit to Appliance Data

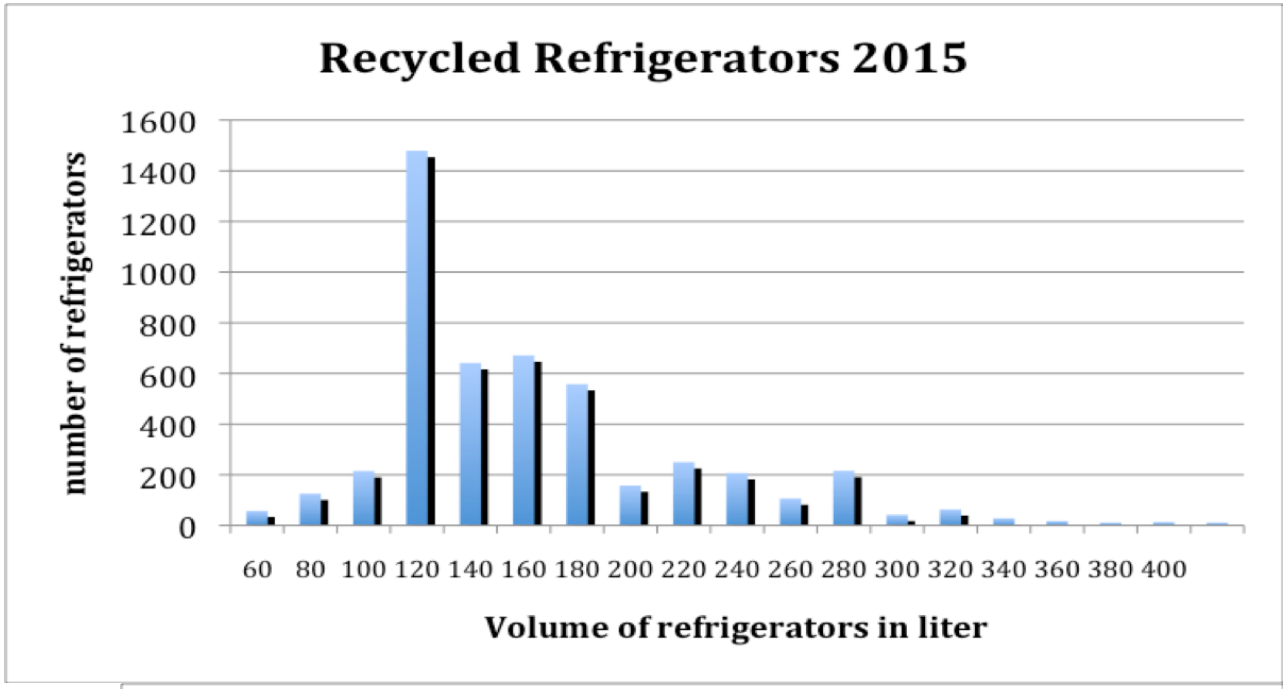


Variation of Iso-butane Charge at Optimal Efficiency

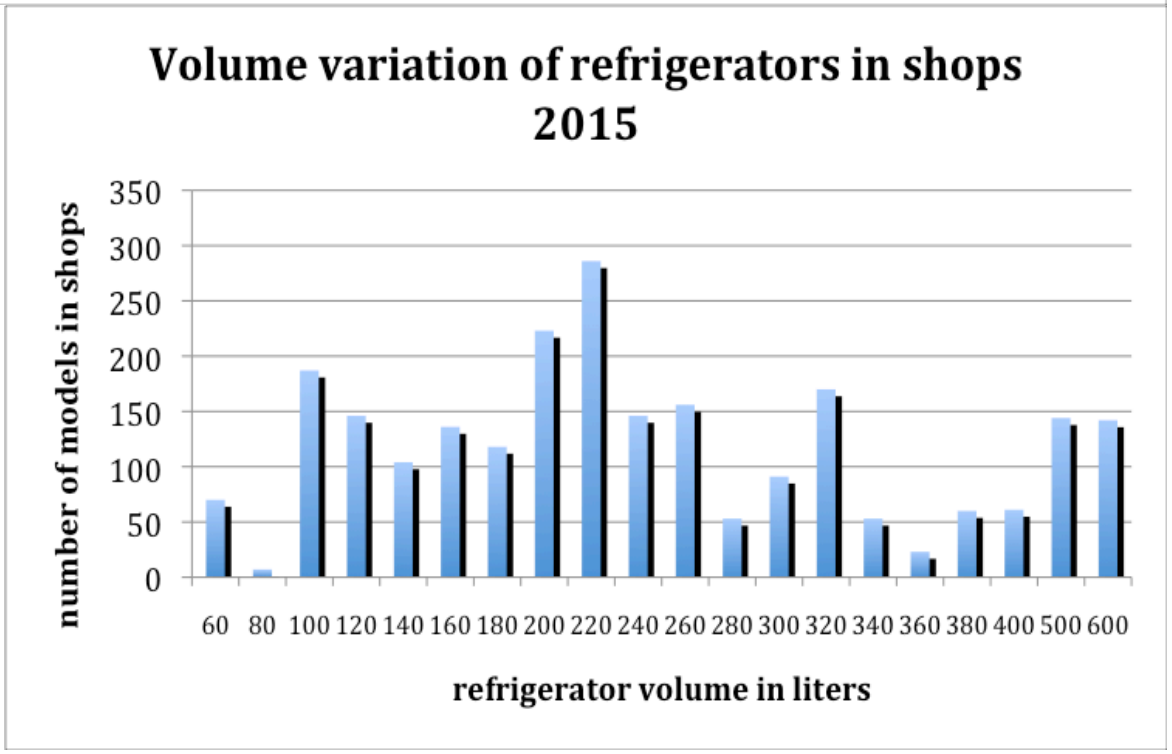


Most efficient manufacturer EEI 41, least efficient one EEI 73

	SECavr	EEIavr x 100	
Samsung	1.143	41.6	
LG	1.721	62.1	
Akai	1.405	42.6	
Haier	1.328	63.2	
Suzika	2.00	71.6	
Sharp	2.06	73.1	
Nasco	1.56	48.2	
Michachi	1.68	44.7	
YD	1.94	61.6	
IceKing	1.88	50.3	
Tamashi	1.41	52.5	
Bruhm	1.44	38.3	
Binatone	1.56	57.6	
Protech	1.43	47.5	



Average volume recycled: 164 ltr



Average volume in shops 245 ltr