

# **Energy Efficiency Analysis and Labeling of Household Appliances in Iran**

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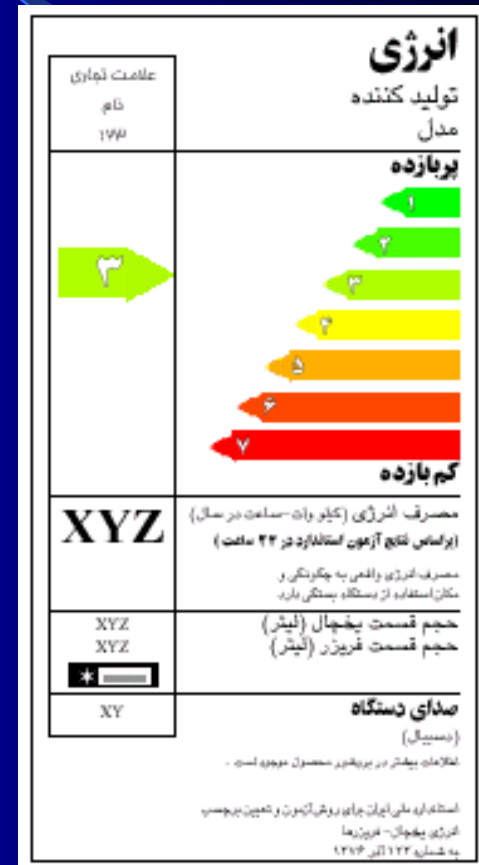
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# Scope of the work

- Refrigerator – Freezers
- Room Air-Conditioners
- Evaporative Coolers
- Hermetic Compressors
- Washing Machines
- Centrifugal Pumps

# Refrigerator - Freezers

- 30 manufacturers of refrigerator-freezers in Iran
- Over 1 million units produced per year
- Average annual energy consumption = 864 kWh/yr
- Standard performance test according to ISO-8187.
- Used climate classification of T (tropical) for Iran
- Tests based on ambient temperature of 32 C
- Expected saving of 1041 GWh for implementing refrigerator-freezer energy label



# Refrigerator-Freezers (3 Year Scheme)

Class of Appliance	M	N
Lader Fridge	0.379	398
Refrigerator/Chiller	0.379	398
Refrigerator no Star	0.379	398
Refrigerator *	1.045	310
Refrigerator **	0.731	398
Refrigerator ***	1.068	382
Fridge/Freezer *(***)	1.263	492
Upright Freezer	0.767	465
Chest Freezer	0.725	294

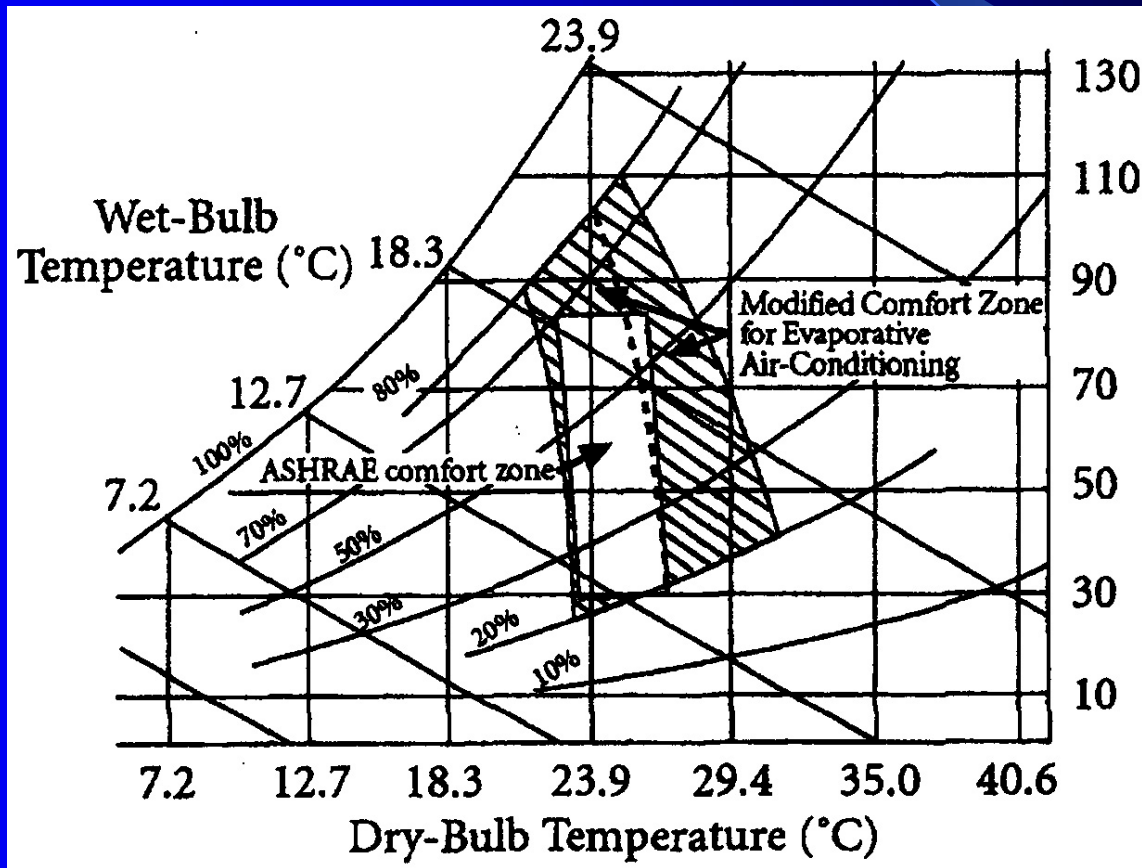
Class of Appliance	M	N
Lader Fridge	0.333	350
Refrigerator/Chiller	0.333	350
Refrigerator no Star	0.333	350
Refrigerator *	0.92	273
Refrigerator **	0.644	350
Refrigerator ***	0.939	336
Fridge/Freezer *(***)	1.11	433
Upright Freezer	0.675	408
Chest Freezer	0.638	259

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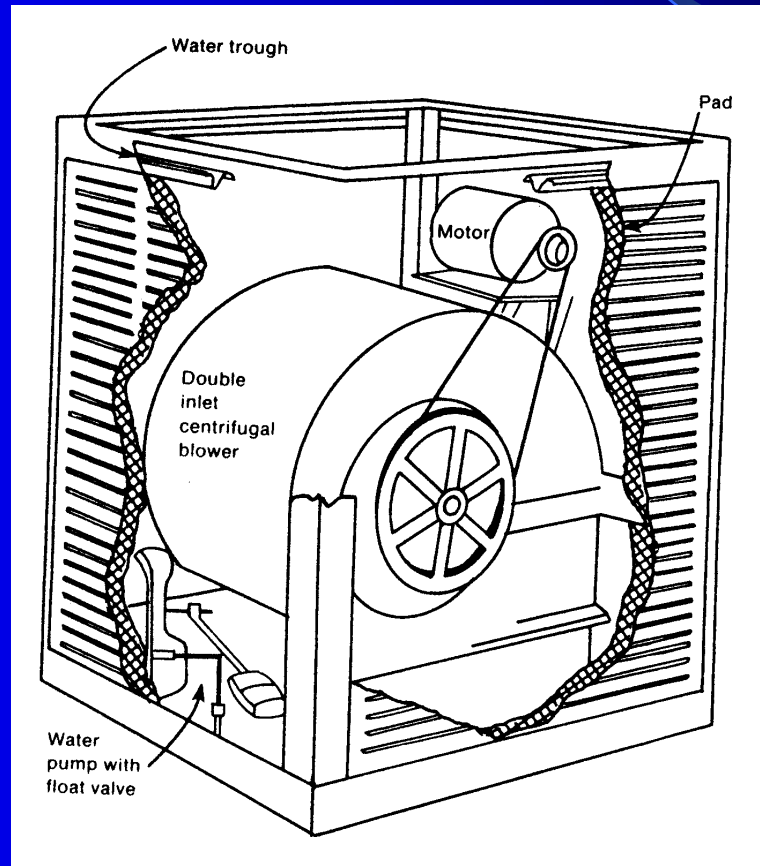
# Evaporative Air Conditioners

- **Direct evaporative coolers** : Operate at constant enthalpy or constant wet-bulb temperature. In this process water gains required heat from the air to evaporate and consequently air cools.
- **Indirect evaporative coolers** : Operate in a process just the same as that of mechanical cooling. In this process use is made of a heat exchanger to exchange heat between wet and cooled air and required indoor air and therefore air cools without gaining any moisture.

# Evaporative Cooler Comfort Zone



# Schematic of a Direct Evaporative Cooler



# Iranian Standard Performance Testing of Evaporative Coolers

Test room facilities constructed according to national standard of Iran for evaporative coolers and AS-2913-1987 and ASHRAE standards

- Evaporative efficiency calculations
- Air flow rate measurement
- Power consumption measurement
- Geometrical measurements

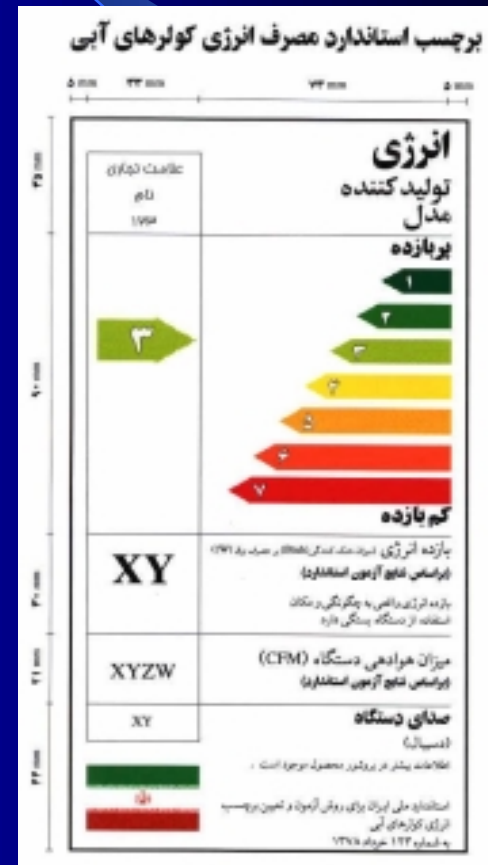


# Evaporative Cooler Design Efficiency Improvements

- High efficiency fans
- High efficiency electromotors and suitable selection for the required load
- Optimized power transmission system (belt,bearing,..)
- Casing insulation
- High performance evaporative media
- Innovative technologies

# Evaporative Cooler Energy Label

$EER > 65$	1
$58.5 \leq EER < 65$	2
$52 \leq EER < 58.5$	3
$45.5 \leq EER < 52$	4
$39 \leq EER < 45.5$	5
$32.5 \leq EER < 39$	6
$26 < EER < 32.5$	7



# Hermetic Compressors

- Used in refrigerators, water coolers, room air-conditioners
- Two manufacturers with 2 million units per year manufacturing capacity
- Energy Efficiency Ratio measured based on ISO-3138
- Minimum Energy Efficiency Ratio Standard

# Compressor Energy Efficiency Improvement Design Analysis

- **Rating Point Model:** Theoretical modeling of a compressor is established based on its standard rating point data and the model extrapolates compressor's refrigerant flow rate (or its refrigeration capacity) and power consumption at off-rating point conditions.
- **Map Based Compressor Model:** Experimental characteristic curves of compressor's power consumption, refrigerant mass flow rate or the cooling capacities are provided by the manufacturer as a function of condensing and evaporating temperatures.
- **Loss and Efficiency Model:** Using internal energy balance of reciprocating compressors, physical and geometrical data, internal efficiency and heat losses, the performance of a compressor is modeled using highly theoretical relations.

# EER Levels for Compressors (1/8, 1/6, 1/5, 1/4 HP)

Level 1	$\geq 5.0$
Level 2	4.73 – 5.0
Level 3	4.42 – 4.73
Level 4	4.11 – 4.42
Level 5	3.80 – 4.11
Level 6	3.50 – 3.80
Level 7	3.19 – 3.50

Level 1	$\geq 4.92$
Level 2	4.63 – 4.92
Level 3	4.34 – 4.63
Level 4	4.05 – 4.34
Level 5	3.77 – 4.05
Level 6	3.45 – 3.77
Level 7	3.19 – 3.45

Level 1	$\geq 507$
Level 2	4.79 – 5.07
Level 3	4.51 – 4.79
Level 4	4.23 – 4.51
Level 5	3.95 – 4.23
Level 6	3.67 – 3.95
Level 7	3.39 – 3.67

Level 1	$\geq 496$
Level 2	4.70 – 4.96
Level 3	4.44 – 4.70
Level 4	4.17 – 4.44
Level 5	3.91 – 4.17
Level 6	3.64 – 3.91
Level 7	3.38 – 3.64

# Room Air Conditioners

- Mostly imported air-conditioners, 150,000 manufactured locally.
- Average air conditioner energy consumption = 720 Kwh/year.
- Analytical modeling of a typical 24,000 Btu/hr air conditioner.
- Weather data parametric study of room air conditioners energy consumption in Iran.

# Washing Machines

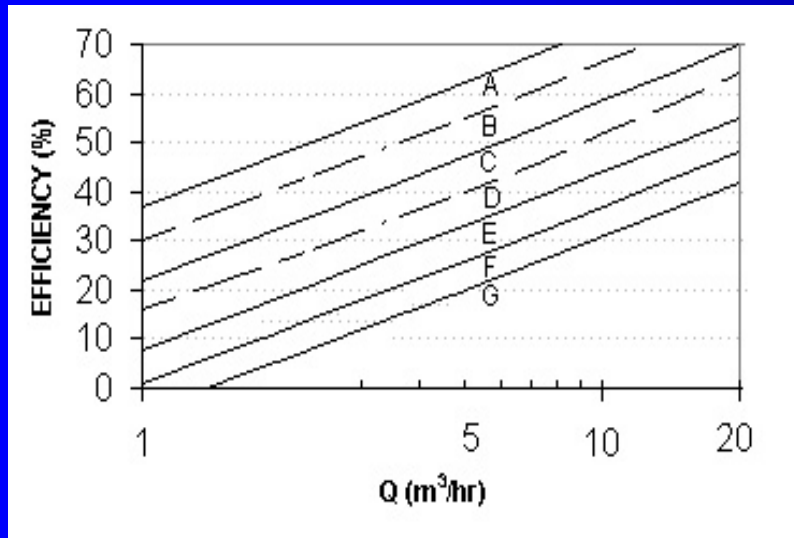
- Over 350,000 units manufactured yearly in Iran.
- Standard test performance (IEC-60456) of 12 typical Iranian washing machines.
- Development of energy label based on European label.
- Average EU label = 0.26 kWh/kg

# Centrifugal Pumps

- Standard performance testing of 11 typical centrifugal pumps.
- Standard Performance tests based on class C of ISO-2548 test procedure.
- Energy efficiency rating based on fluid flow rate through the pump.



# Centrifugal Pumps Energy Efficiency Label



انرژی	
تولید کننده مدل	
H-3	
پربازده	
کم بازده	
راندمان حداکثر (بر اساس نتایج آزمون استاندارد ایزو ۲۵۴۸)	
۷۷/۰۲	
۲/۶	هد (متر)
۷/۱	دبی (متر مکعب بر ساعت)
۱۴۵۰	سرعت دوران (دور در دقیقه)
۲	قطر آبدهی (اینچ)
.....	صدای دستگاه (دسیبل)

# Conclusions

Energy efficiency Analysis and labeling of refrigerator-freezers, evaporative coolers, hermetic compressors, washing machines and pumps based on:

- Establishment of a standard test performance facility.
- Producing an analytical simulation model and studying the effect of efficiency improvement design options.
- In depth knowledge and understanding of manufacturing abilities and study of ways of energy efficiency improvements.
- Development of energy labels with active participation of manufacturing representatives.