Utility Energy Forum – Technology View

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Residential Laundry – Current and Future Technology

Clothes Washers

Front vs. Top Load

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Clothes Washer Product Types and Minimum Performance Standard (per DOE §430.32)

Product Class	Integrated Modified Energy Factor (IMEF) (cu.ft./kWh/cycle)	Integrated Water Factor (IWF) (gal/cycle/cu.ft.)
Top-loading, Compact (less than 1.6 ft^3 capacity)	1.15	12.0
Top-loading, Standard (1.6 ft^3 or greater capacity)	1.57	6.5
Front-loading, Compact (less than 1.6 ft^3 capacity)	1.13	8.3
Front-loading, Standard (1.6 ft^3 or greater capacity)	1.84	4.7

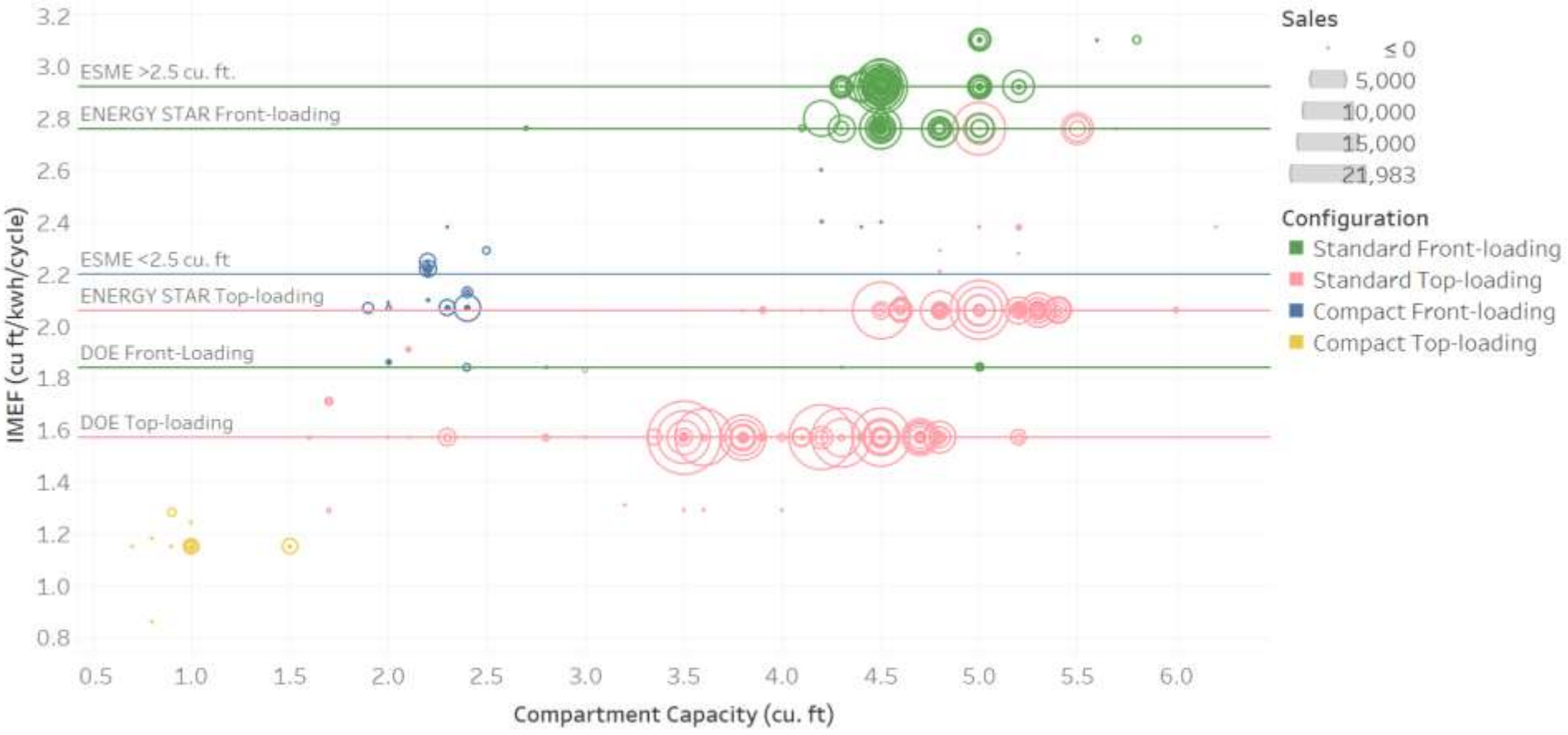
Current ENERGY STAR Requirements

Product Type	Integrated Modified Energy Factor (IMEF) (cu.ft./kWh/cycle)	Maximum IWF (Integrated Water Factor) (gal/cycle/cu.ft.)
Residential Clothes Washers, Front-loading (> 2.5 cu-ft)	2.76	3.2
Residential Clothes Washers, Top-loading (> 2.5 cu-ft)	2.06	4.3
Residential Clothes Washers (≤ 2.5 cu-ft)	2.07	4.2

- Clothes washers under 1.6 ft^3 are excluded from ENERGY STAR.
- ENERGY STAR incentivizes smart grid and connected functionality by providing an energy allowance.
- Energy Solutions found an average IMC of $207 using web-scraped data for ENERGY STAR qualifying products compared to nonqualifying products.[1]

[1] See Figure 7 in the Clothes Washers Memo

Energy Metric by Product Class



NEEA RPP Sales Data (Jan 2020-May 2021)

ESME = ENERGY STAR Most Efficient

Top-loading

- Average efficiency is far below the ENERGY STAR criteria
- Product clustering occurs along ENERGY STAR and DOE requirements levels
- The lack of separate ESME criteria makes it difficult to distinguish or incentivize more efficient products

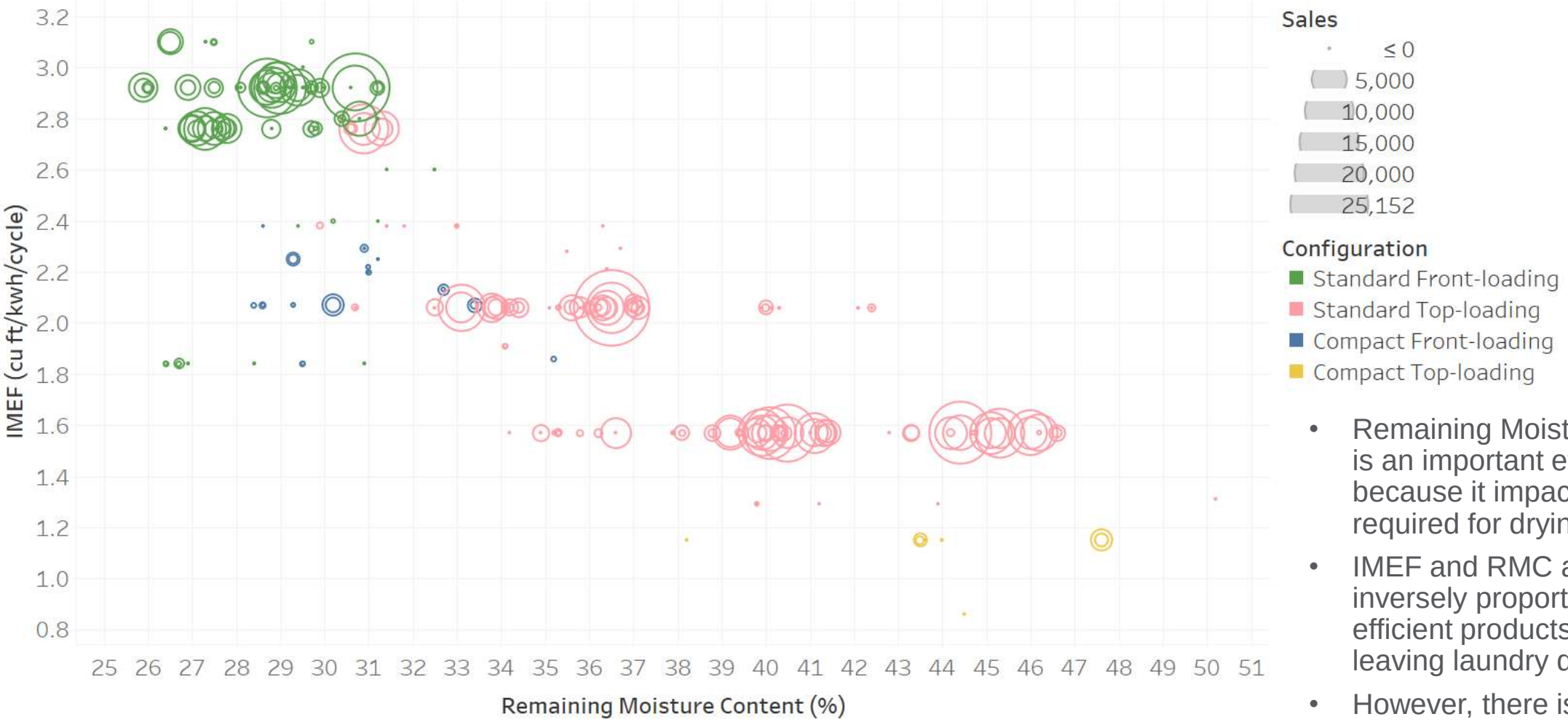
Front Loading

- The ENERGY STAR criteria is lower than the average unit efficiency

Compact

- Units under 2.5 ft^3 have separate qualification levels
- Units that meet the DOE compact definition are excluded from ENERGY STAR (under 1.6 ft^3)

Remaining Moisture Content by Product Class

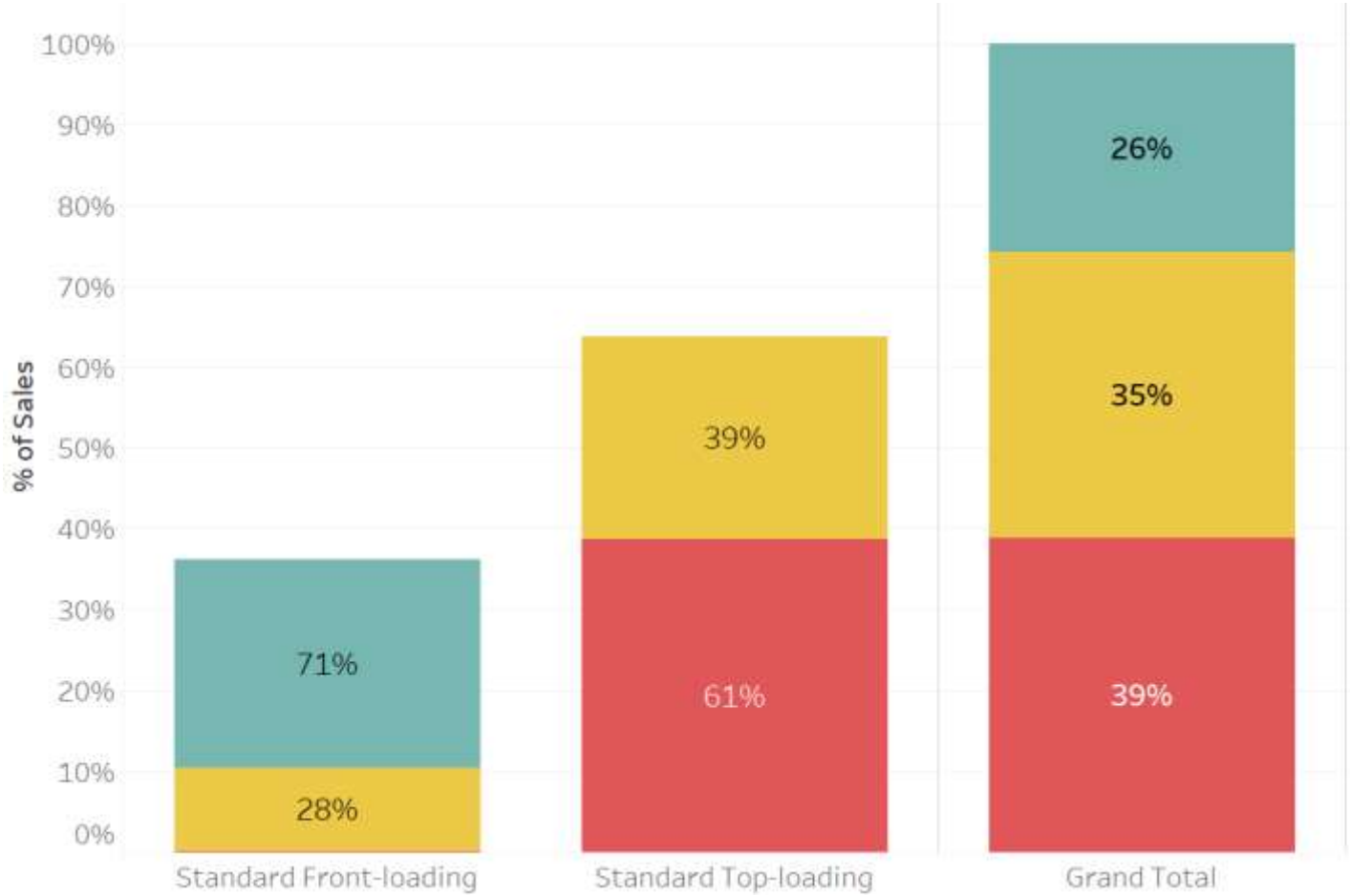


NEEA RPP Sales Data (Jan 2020-May 2021)

- Remaining Moisture Content (RMC) is an important efficiency metric because it impacts the energy required for drying.
- IMEF and RMC are generally inversely proportional – the more efficient products are also better at leaving laundry drier.
- However, there is a large spread of RMC within a single IMEF level and there is no RMC requirement in ENERGY STAR.

ENERGY STAR qualification by DOE Product Class

Basic ENERGY STAR market penetration or better is 60%



Top-loading:

- ~60% of total sales
- ENERGY STAR penetration is reasonable, but no products meet the current ESME (ENERGY STAR Most Efficient) level

Front-loading:

- 70% of sales are ESME

NEEA RPP Sales Data (Jan 2020-May 2021)

Washer Product Development Roadmap

	Pre-2020	2020	2021	2022	2023	2024
Top Load						
Top Load Agitator						
Top Load Impeller						
Extra-large Capacity						
Front Load						
Standard Front Load						
Extra-large Capacity						
Compact Front Load						
Emerging Technology						
Ultrasonic						
Washer Beads						
CO2	Commercial Applications					
General Features						
Steam Wash						
AI/Smart Software						
WiFi Connected						

Use declining
Use unchanged
Use increasing

Agitators and Impellers

Top loader with impeller is first ESME top load washer

- Rub clothes against agitator
- Shorter wash times

- Rub clothes against other clothes
- Lower remaining moisture due to increased spin speed
- More room for bulky items

Clothes Dryers

Product Types (per DOE §430.32)

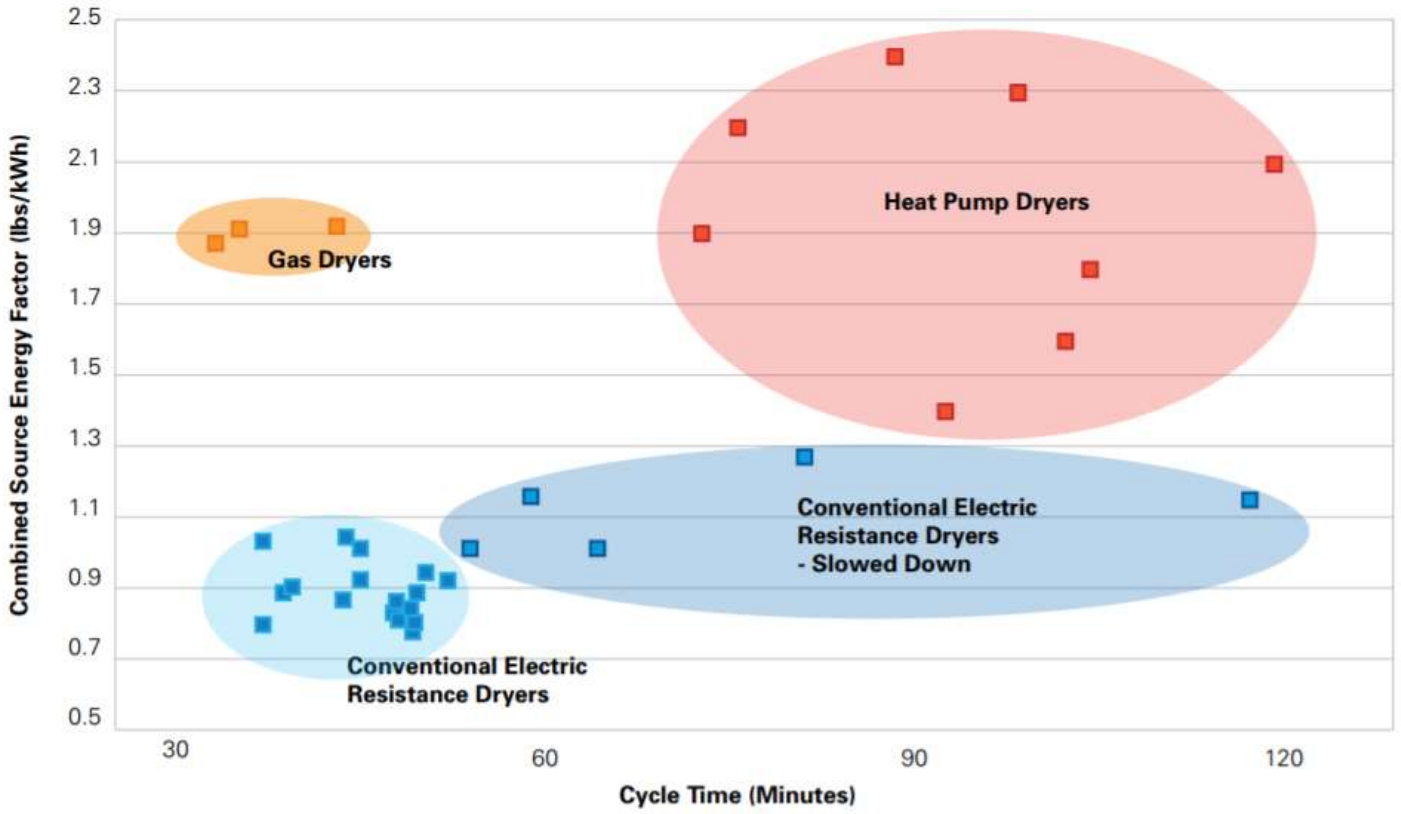
Product Class	DOE minimum criteria for Combined Energy Factor (CEF) (lbs/kWh)
Vented Gas	3.30
Ventless or Vented Electric, Standard (4.4 ft^3 or greater capacity)	3.73
Ventless or Vented Electric, Compact (120V) (4.4 ft^3 or greater capacity)	3.61
Vented Electric, Compact (240V) (less than 4.4 ft^3 capacity)	3.27
Ventless Electric, Compact (240 V) (less than 4.4 ft^3 capacity)	2.55
Ventless Electric Combination Washer/Dryer	2.08

Current ENERGY STAR Requirements

Product Type	Minimum Combined Energy Factor (CEF) criteria (lbs/kWh)
Vented Gas	3.48
Ventless or Vented Electric, Standard (4.4 ft^3 or greater capacity)	3.93
Ventless or Vented Electric, Compact (120V) (4.4 ft^3 or greater capacity)	3.80
Vented Electric, Compact (240V) (less than 4.4 ft^3 capacity)	3.45
Ventless Electric, Compact (240 V) (less than 4.4 ft^3 capacity)	2.68

- The Energy Star specification incentivizes smart grid functionality/connected functionality by providing a connected energy allowance.
- Recommend increasing the minimum CEF criteria for gas dryers to match that of electric dryers.
- Recommend analyzing the difference in MSRP for ENERGY STAR and non-ENERGY STAR products of comparable size and type.

Background on Heat Pump Dryers



Heat pump units average 36% savings over standard clothes dryers vs. 22% savings for efficient clothes dryers

Heat pump dryers typically have long cycle times

Some hybrid heat pump dryers have a “speed mode” which uses conventional electric resistance

Gas clothes dryers have short cycle times and high source energy savings if electricity is being generated by natural gas.

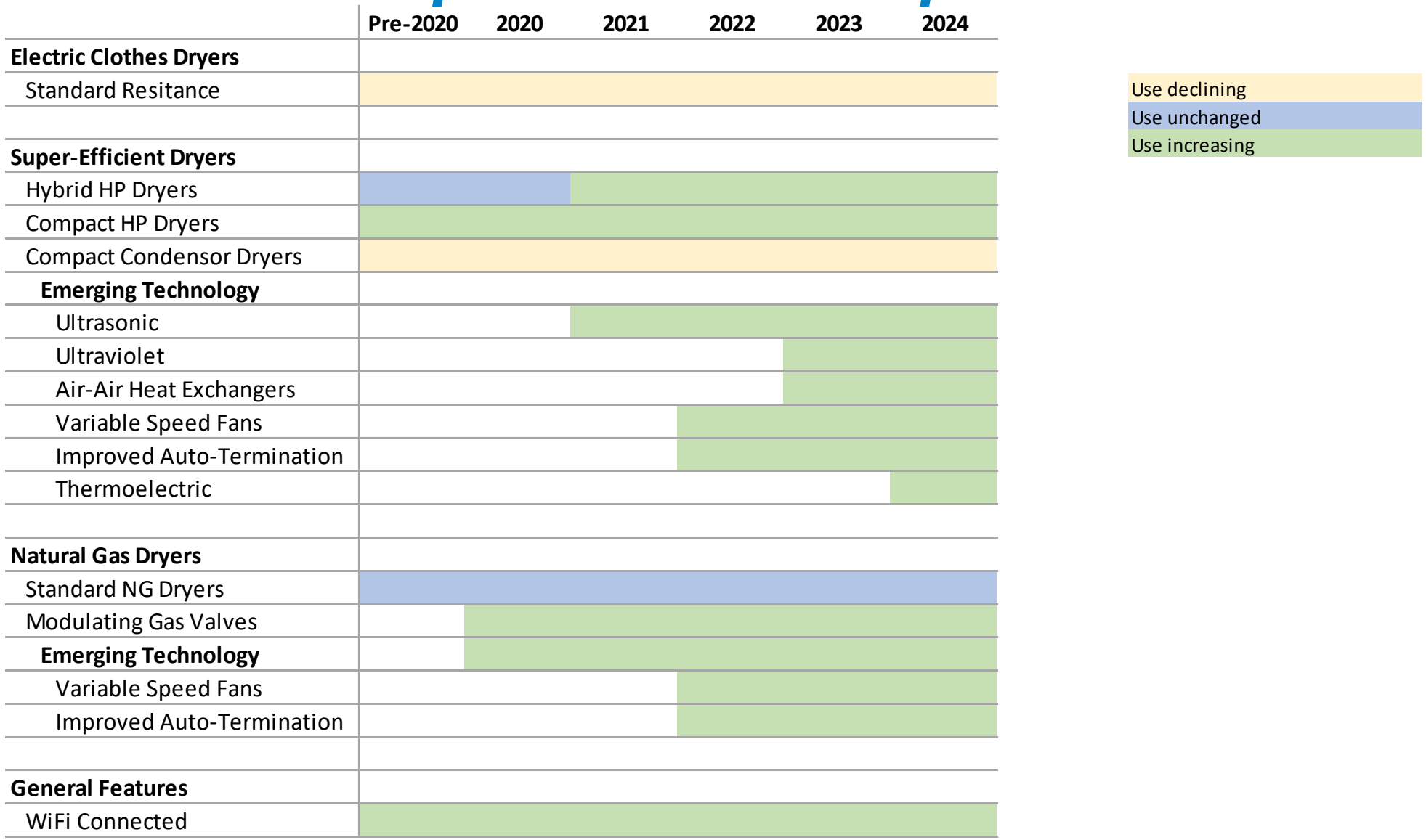
Retrofitting homes/businesses from Gas to Electric or Electric to Gas is prohibitive in most cases

Heat pump and gas clothes dryers tend to be more expensive than electric clothes dryers

Dryer QPL

- Models use NEEA's "real world" load in addition to DOE testing
  - Available here
- Available at conduitnw.org or at BPA's website
- 4 models are currently undergoing testing; projected to be added by end of month
  - 2 Whirlpool models are no longer available

Product Development Roadmap



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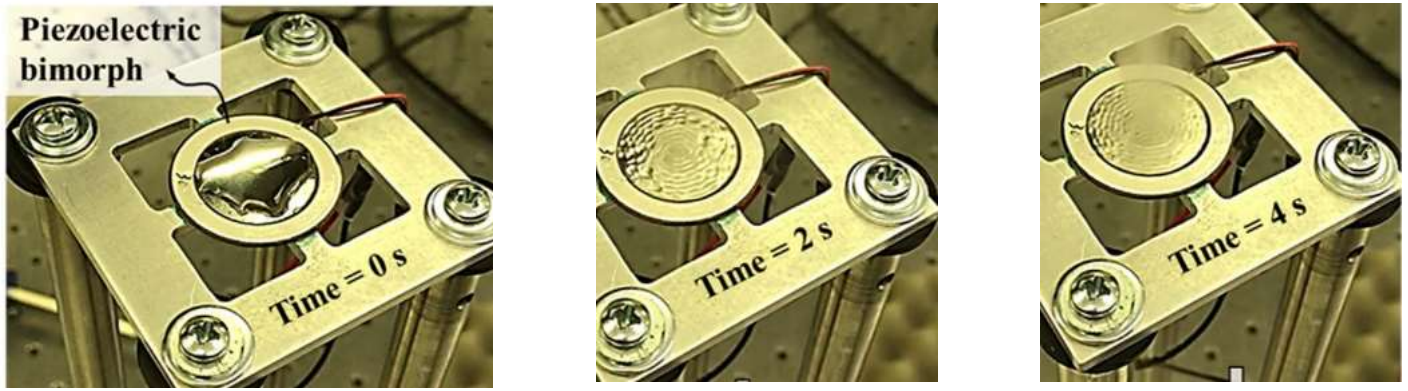
Dryer Balls

- Readily available
- Low cost
- Testing Results: In process
  - Dependent on load size and auto-termination approach
  - Some dryers saw virtually no difference when using dryer balls, others saw significant time and energy savings.
- Results available: Q4 2021

Ultrasonic Dryer

Ultrasonic drying technology uses piezoelectric elements to shake (vibrate) the fabric at high frequency, resulting in moisture removal

– This results in mechanical drying through vibration instead of thermal drying

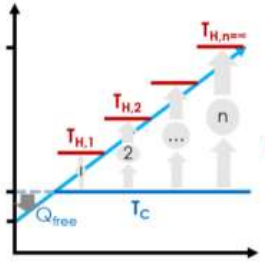


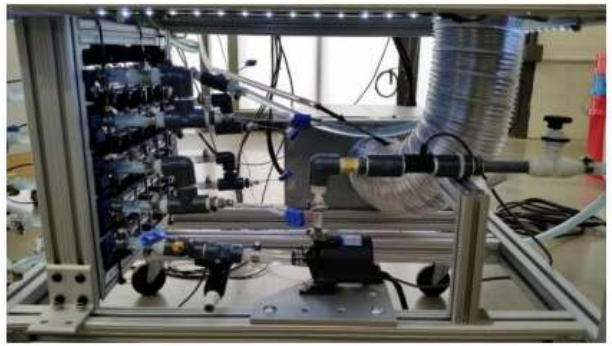
- Lab testing of pre-commercialized product achieved equivalent energy factor (EF) of 5.74 lb/kWh with average drying time of 10.75 minutes for single piece of fabric.
- Throughput is one of the biggest challenges

Patel V., K., 2019, "Ultrasonic Clothes Dryer," 2019 Department of Energy (DOE) Building Technologies Office (BTO) Peer Review, Arlington, Virginia. Available at:

ORNL's Prototype Thermoelectric Dryer (TED)

- CRADA project with Samsung
- Thermoelectric heat pump
  - No refrigerant
  - Solid state
  - Modularity leveraged: some TEs have small lift (relevant limit is "infinite Carnot")





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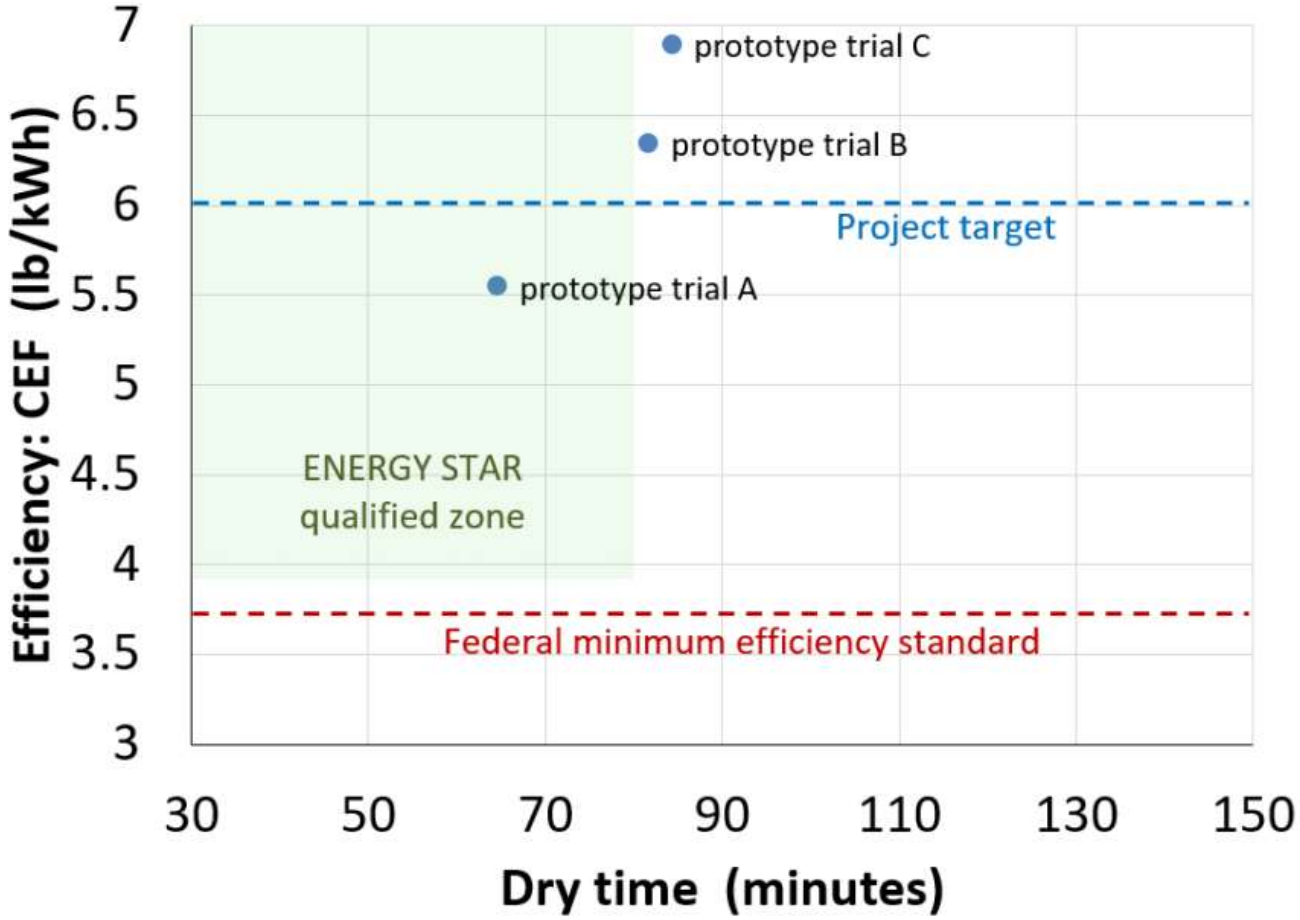
Gluesenkamp, Kyle R., "Heat Pump Technology Potential," presented to the session "Heat Pump Technology Enables Most Efficient Water Heaters and Clothes Dryers" at the 2020 ENERGY STAR Product Partners Meeting, October 27-29, 2020 (virtual). https://2020esppm.pathable.co/meetings/virtual/iXBCJ7WYBgEdfwNjP

ORNL's Prototype Thermoelectric Dryer (TED)

- CEF of 6.89 achieved with dry time of 84 minutes
- CEF of 5.55 with dry time of 65 minutes



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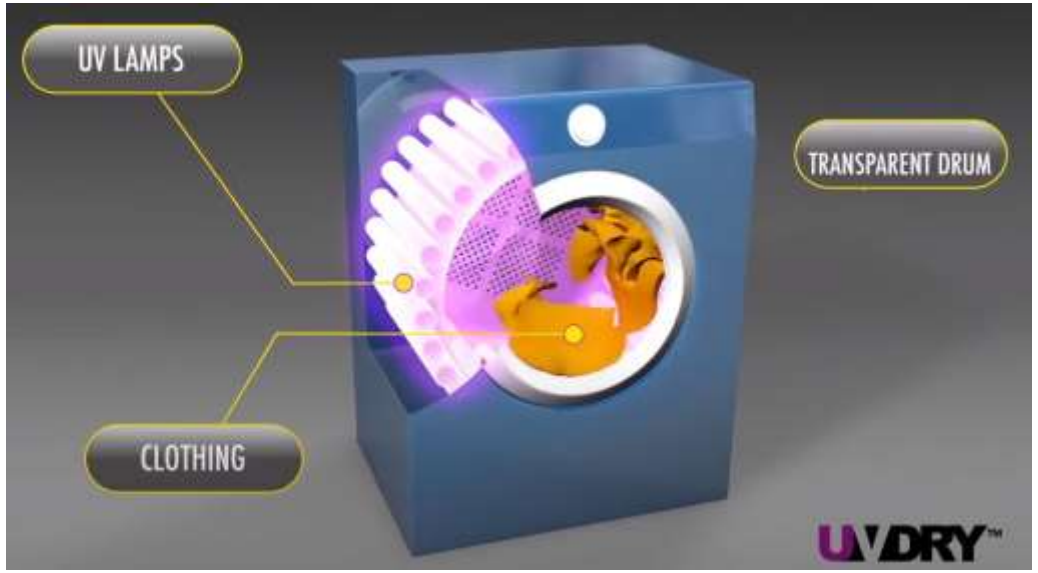
UVdry Ultra-violet dryer



- LED’s generate UV light
- Transparent drum to allow transfer of UV light to textiles
- Potential for large energy savings
- Research will be underway on performance and interaction with textiles

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