U.S. Department of Energy

SOLID-STATE LIGHTING WORKSHOP

Cosponsored by the Illuminating Engineering Society

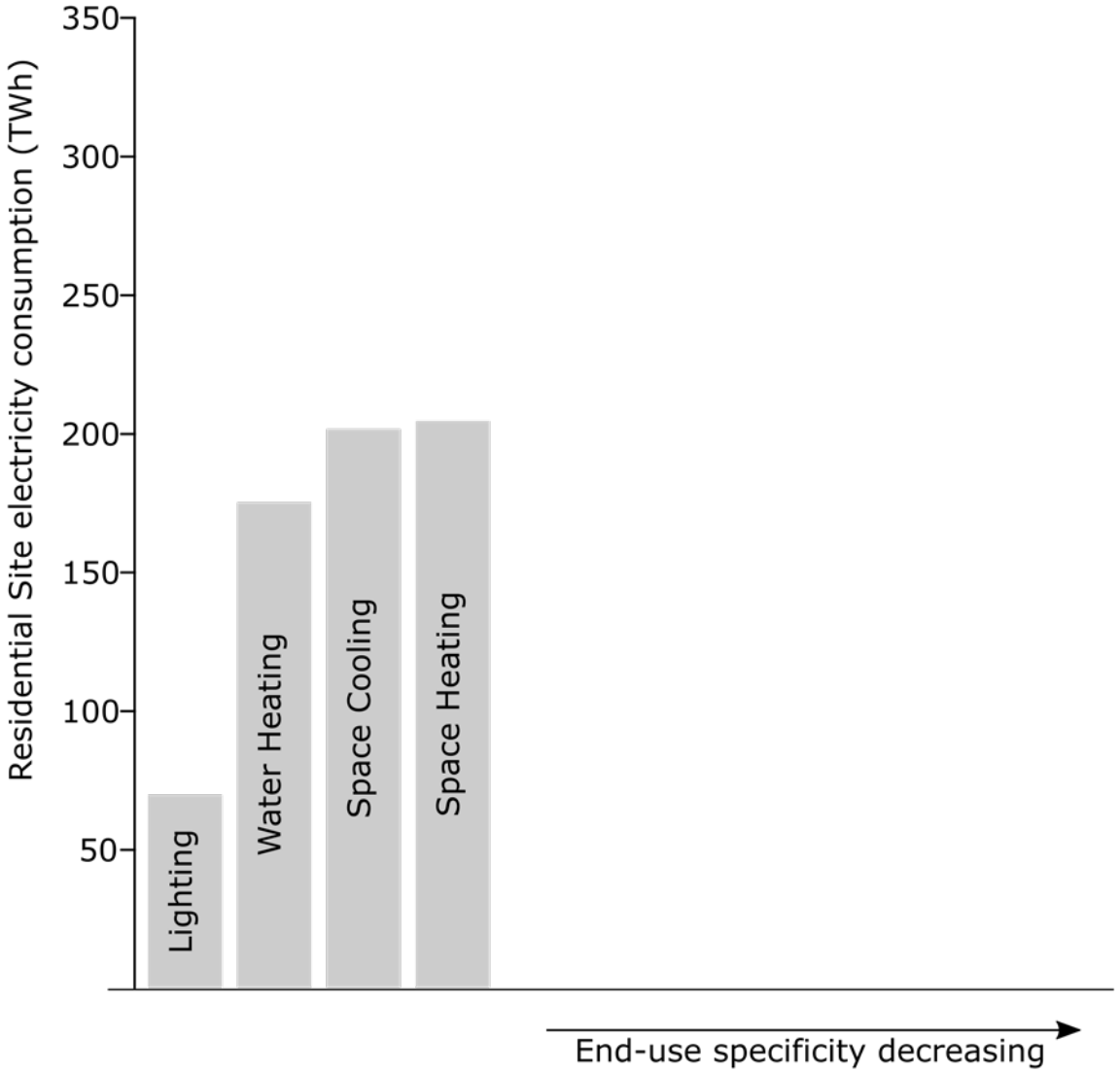
U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

IES Illuminating ENGINEERING SOCIETY

On “other” building loads

Source: EIA 2020 Annual Energy Outlook



STRATEGY

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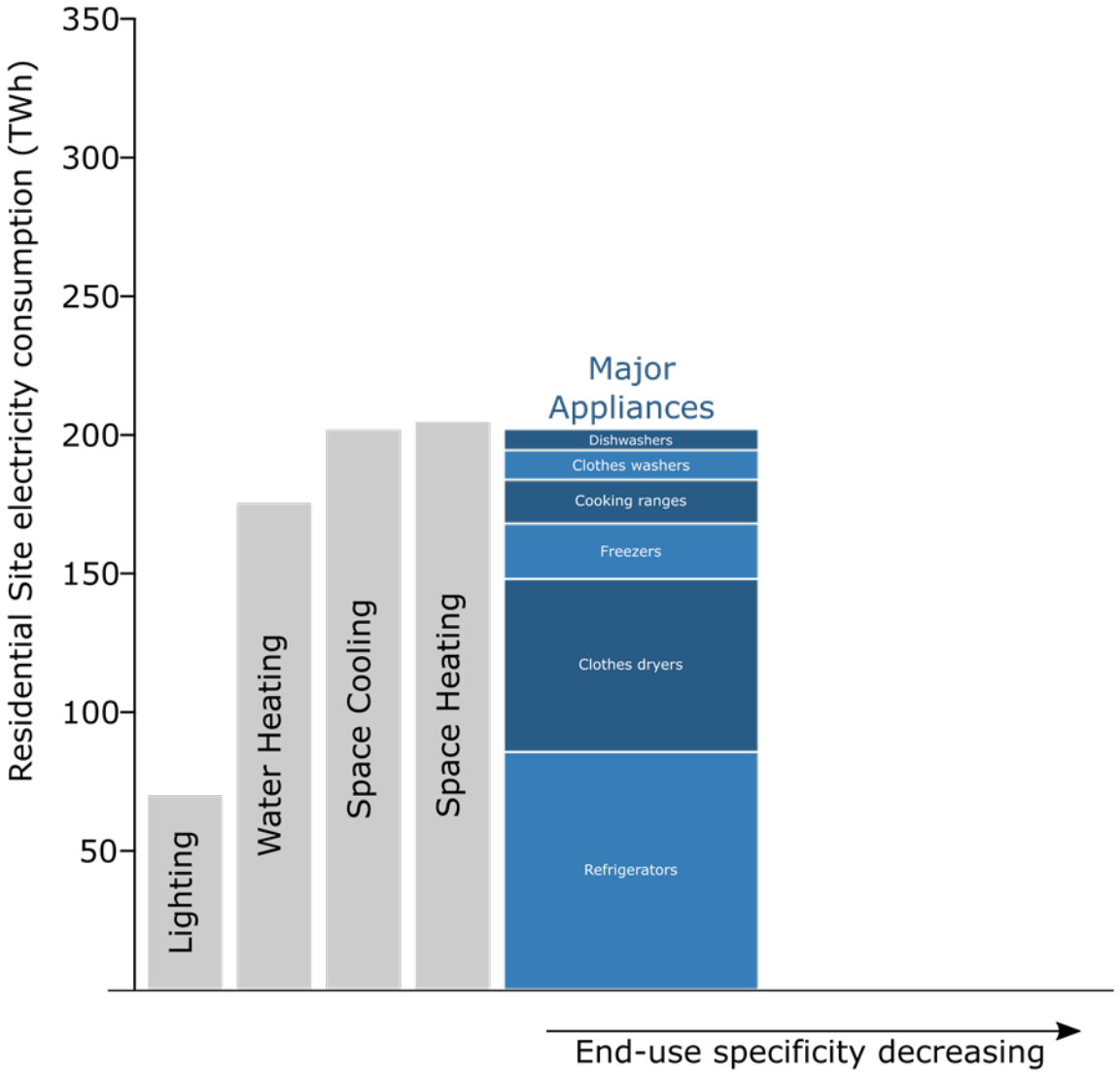
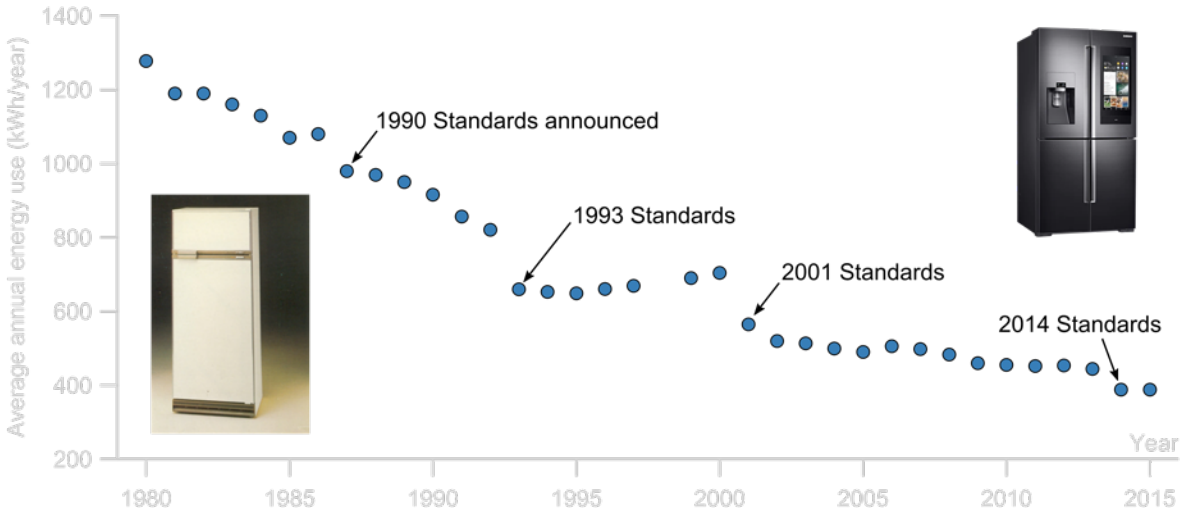


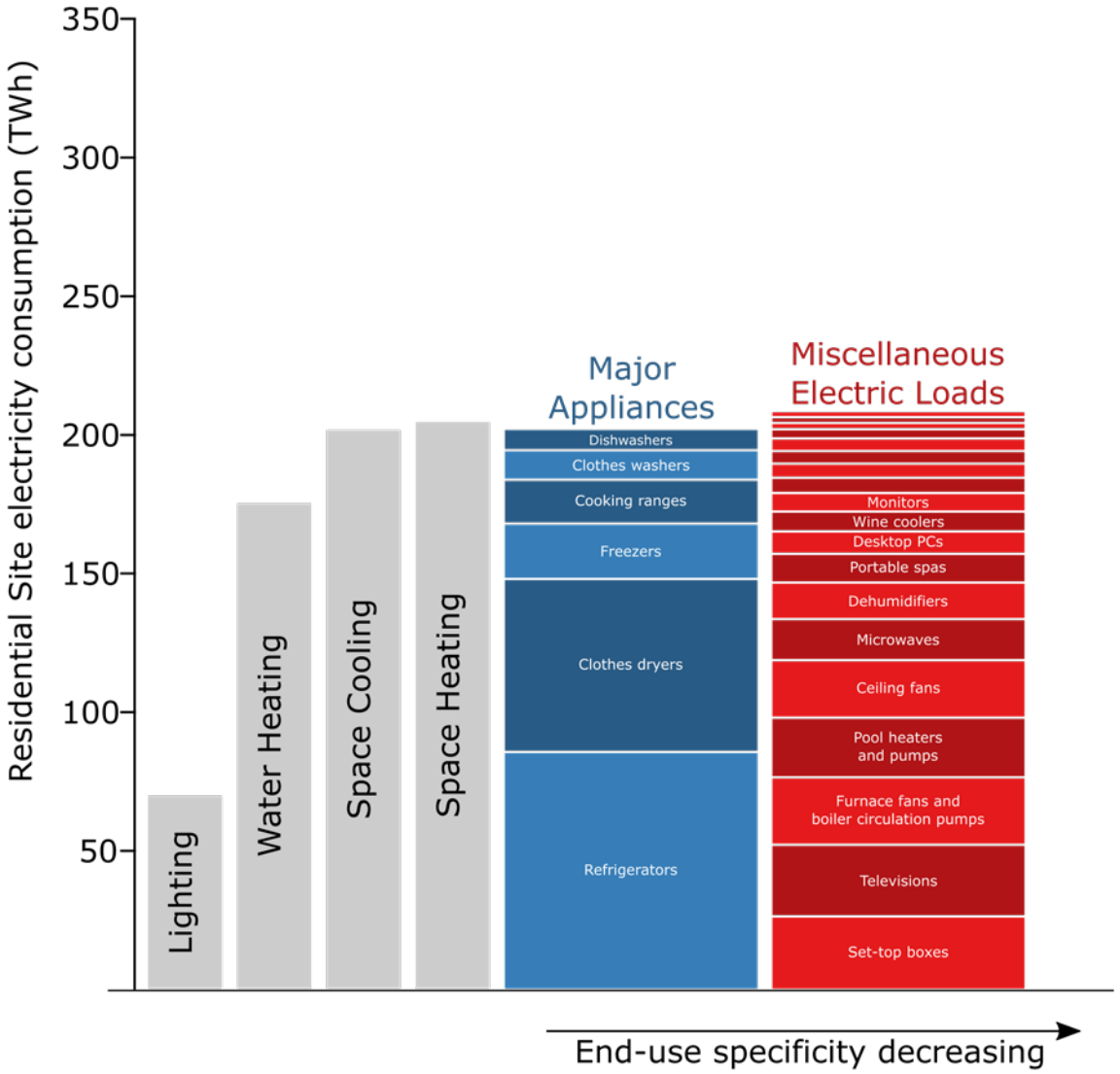


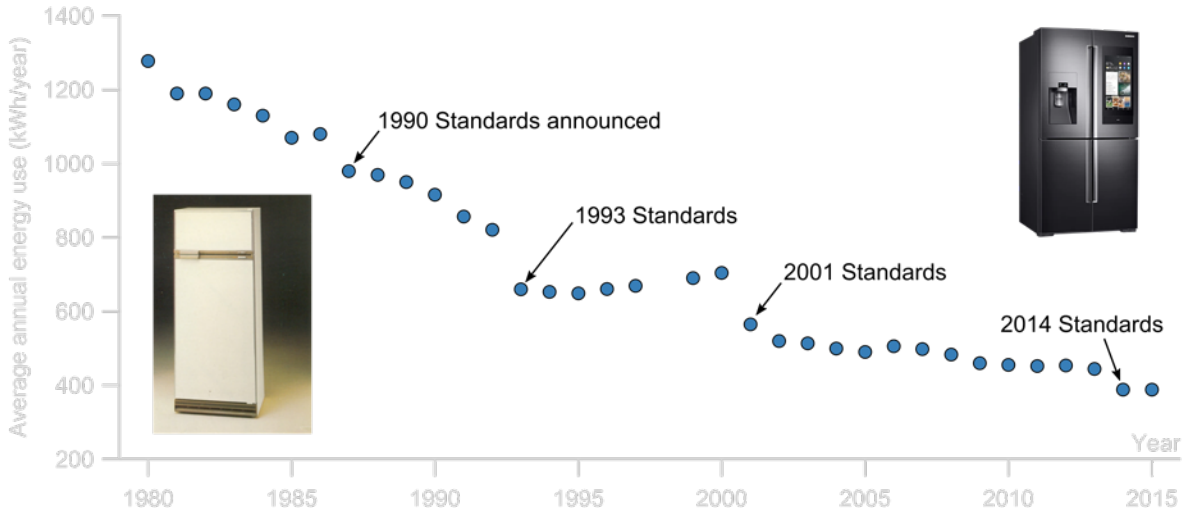
STRATEGY

R&D for device-level efficiency
+ minimum efficiency standards

On “other” building loads

Source: EIA 2020 Annual Energy Outlook





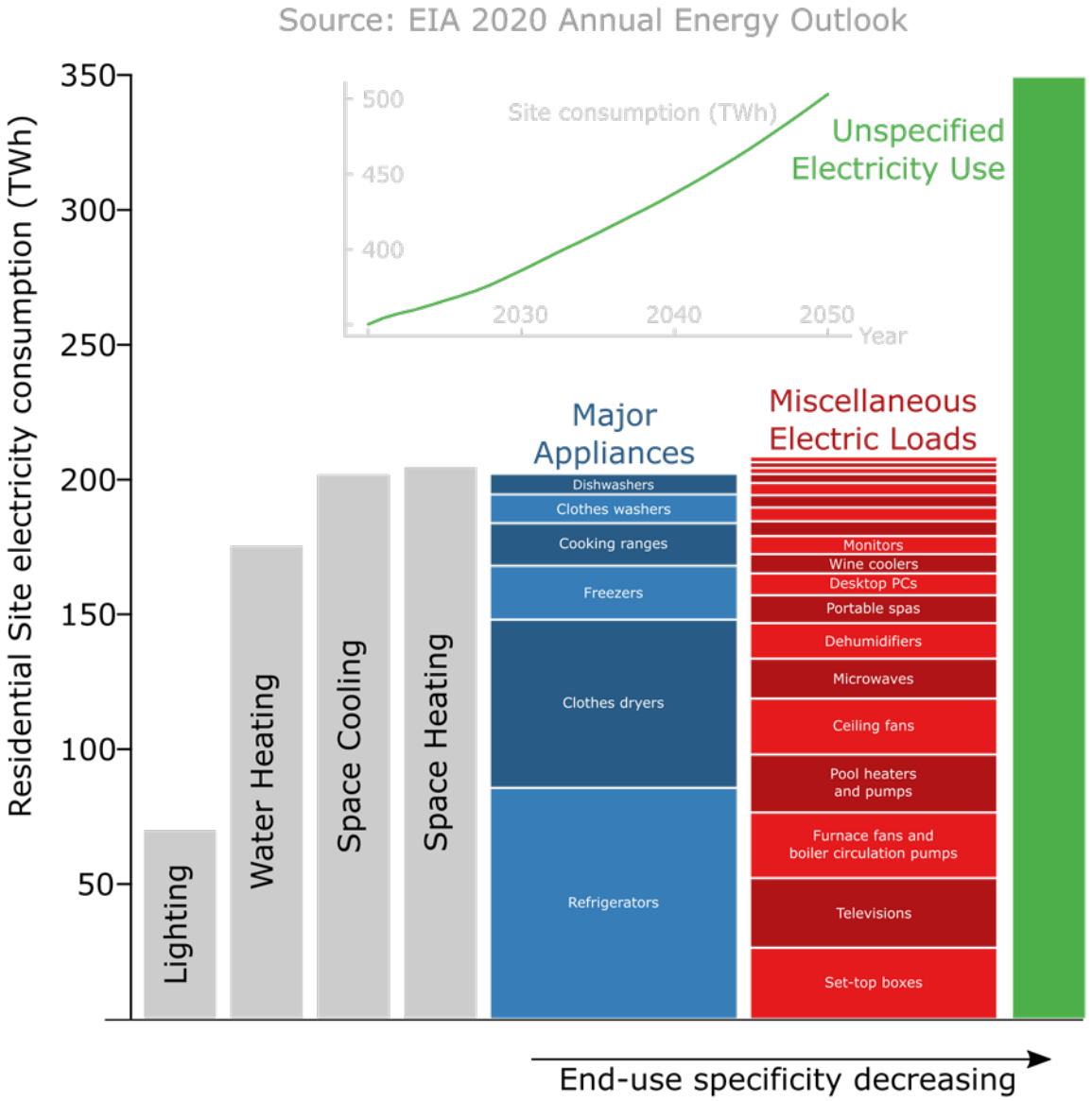
STRATEGY

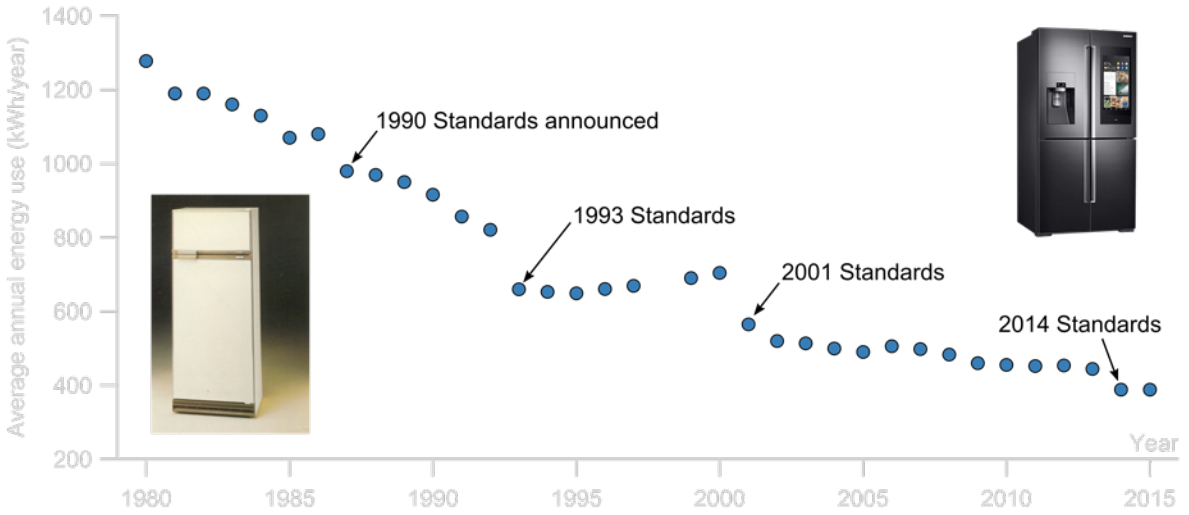
R&D for device-level efficiency
+ minimum efficiency standards

"Cross-cutting topics"

On “other” building loads

Source: EIA 2020 Annual Energy Outlook





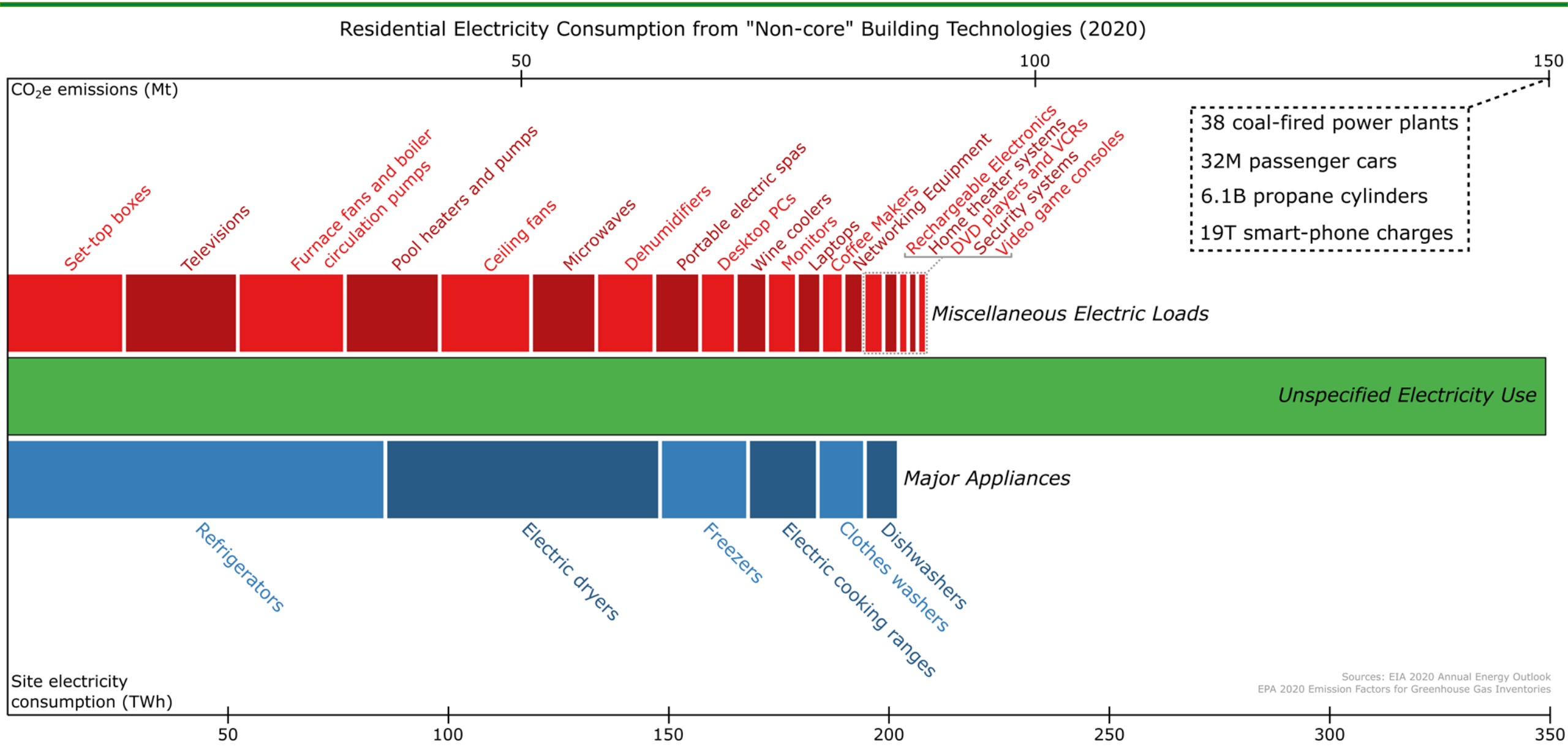
STRATEGY

R&D for device-level efficiency
+ minimum efficiency standards

"Cross-cutting topics"

Information, data, analysis

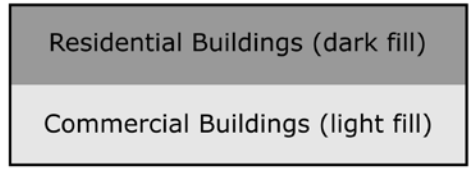
What is the impact of “miscellaneous” electricity use?

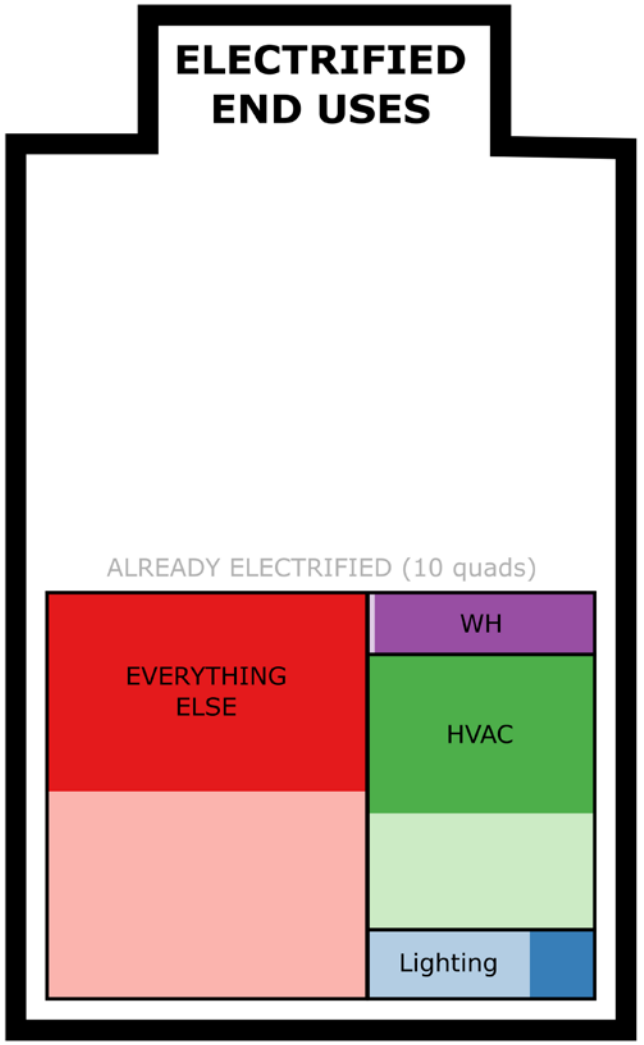


Electricity demand in buildings now and in the future

Site Energy Consumption (2022, projected)

Source: EIA 2021 Annual Energy Outlook





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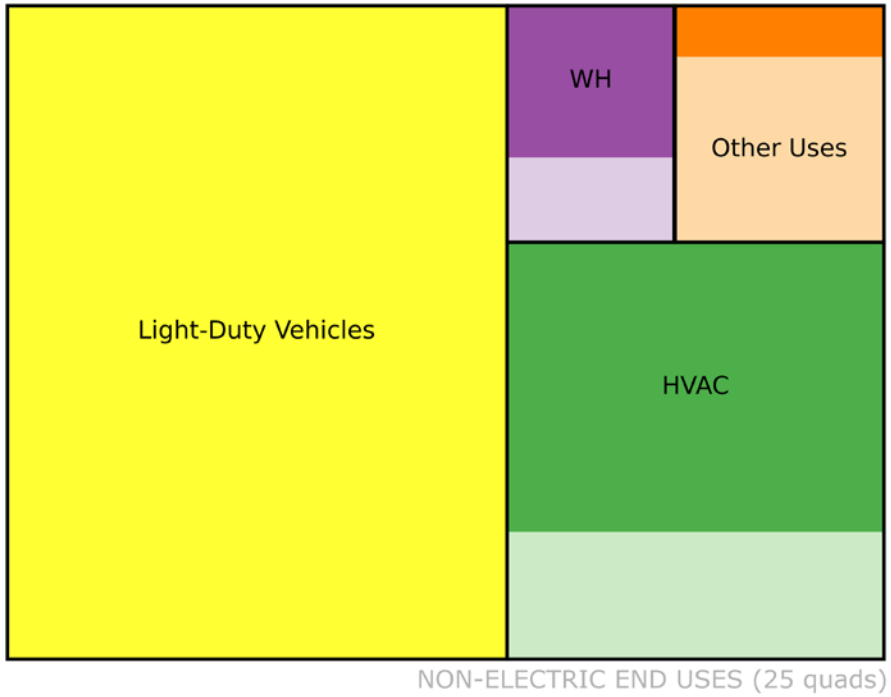
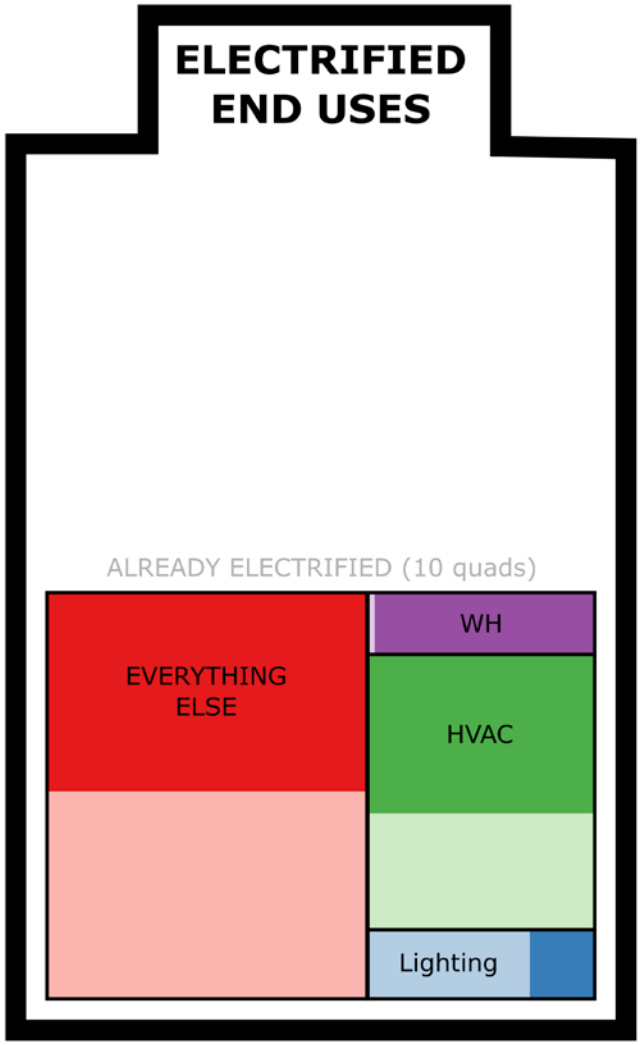


Site Energy Consumption (2022, projected)

Source: EIA 2021 Annual Energy Outlook

Residential Buildings (dark fill)

Commercial Buildings (light fill)



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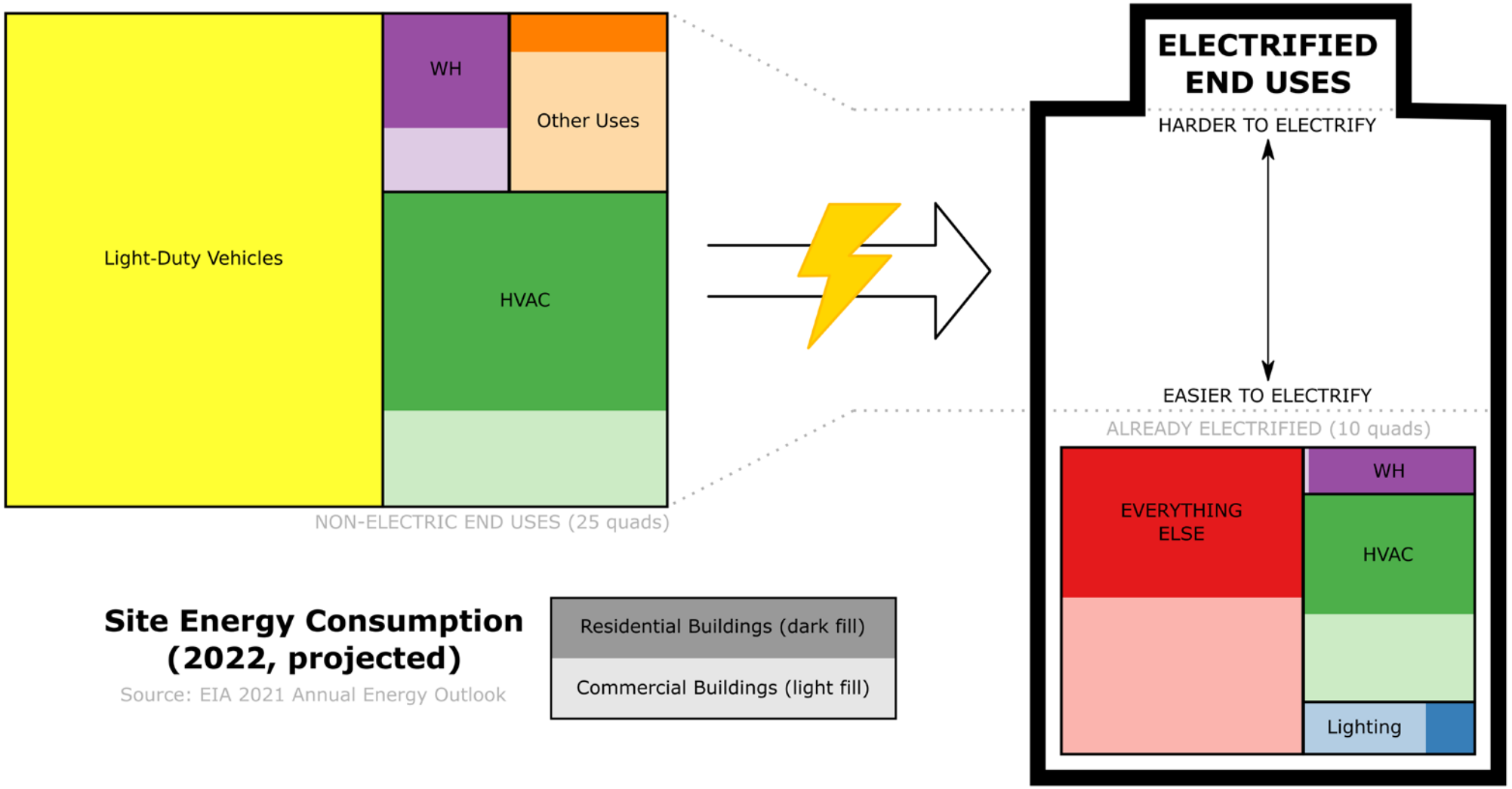


Site Energy Consumption (2022, projected)

Source: EIA 2021 Annual Energy Outlook

Residential Buildings (dark fill)

Commercial Buildings (light fill)

Cross-cutting topics for MELs

- **Power conversion**
  - Power supplies
  - Transformers
  - Native-DC devices
  - Distributed DC power
  - Grid support/frequency regulation
- **Power scaling, modulation, and management**
  - Standby loads, classification and ultralow power
  - Energy harvesting
  - Efficiency across part-loads
  - Part-load loss classification
  - Effective/fast sleep/wakeup modes
  - Interoperable device management
  - Automatic standby/sleep/off
- **Displays/Interfaces**
  - LCD to microLED/OLED technologies
  - Automatic screen dimming
  - Increased interface functionality
- **Measurement and Estimation**
  - NILM and leveraging AMI data
  - Self-measurement and self-reporting
  - Submetering and smart panels
  - Early fault detection
  - Plug-load monitors
- **Lifecycle Analysis**
  - Electronic waste
  - Manufacturing
  - Cloud energy consumption
  - Recycling and reuse
  - Right to repair
- **Communications networks**
  - Combined data/power
  - Improved wireless networks
  - Cybersecurity and privacy

Be in touch!

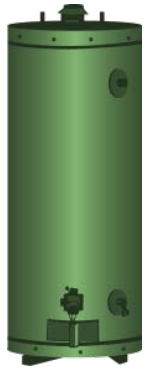
wyatt.merrill@ee.doe.gov

https://www.energy.gov/eere/buildings/building-electric-appliances-devices-and-systems

Defining Building Electric Appliances, Devices, and Systems (BEADS)

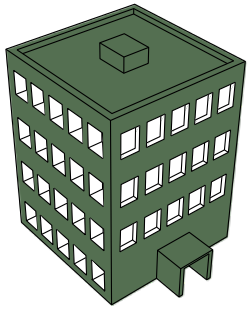
Major Appliances

HVAC



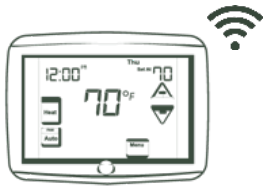
Water Heating

Lighting



Envelope

Windows



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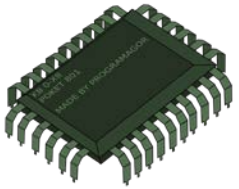
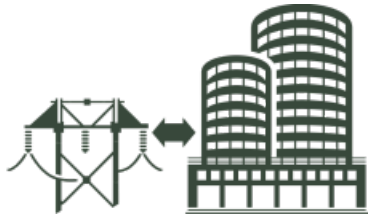


Sensors



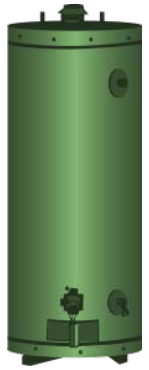
Grid-interactive Efficient Buildings

Building Energy Modeling

Defining Building Electric Appliances, Devices, and Systems (BEADS)

Major Appliances

HVAC

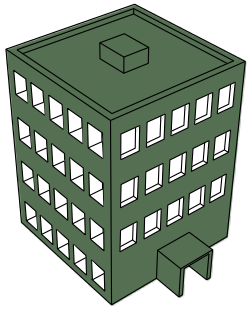


Water Heating

Lighting

Consumption

Consumption modifiers



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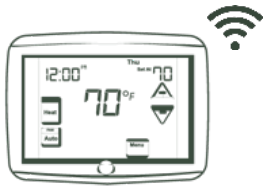

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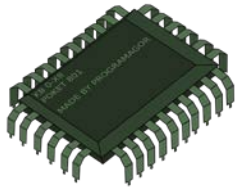

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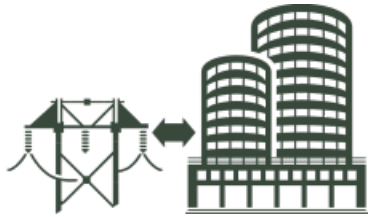

Grid-interactive Efficient Buildings

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Defining Building Electric Appliances, Devices, and Systems (BEADS)

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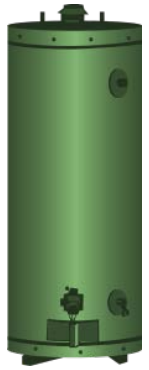


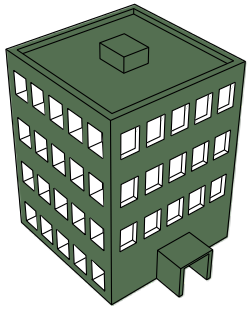
Water Heating

Lighting

What's missing?

Consumption

Consumption modifiers



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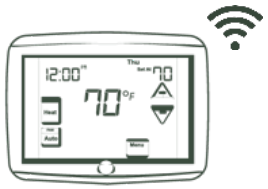

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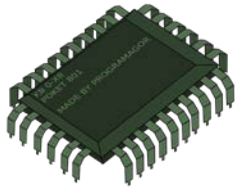

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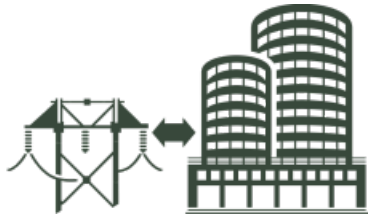
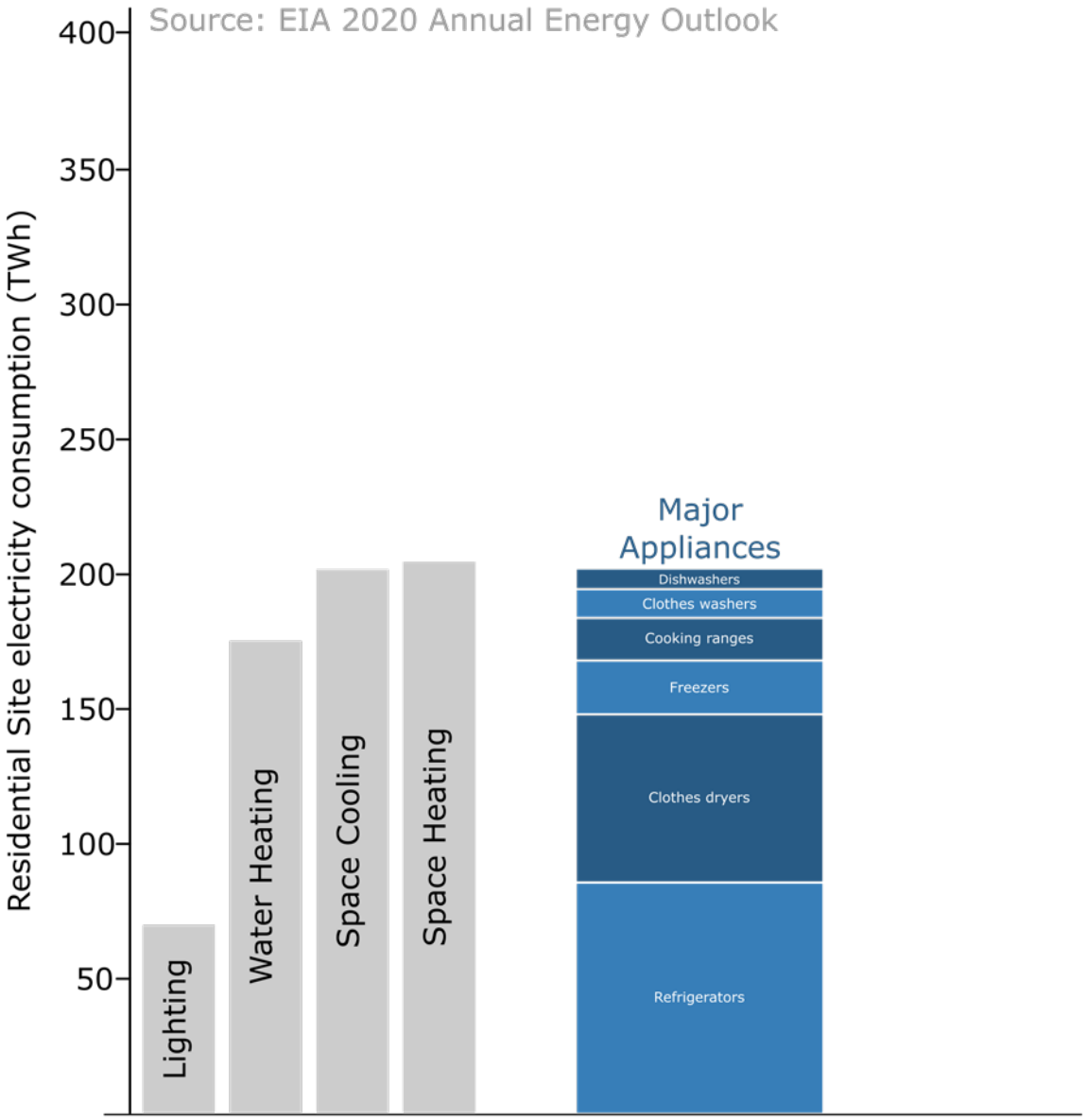


Grid-interactive Efficient Buildings

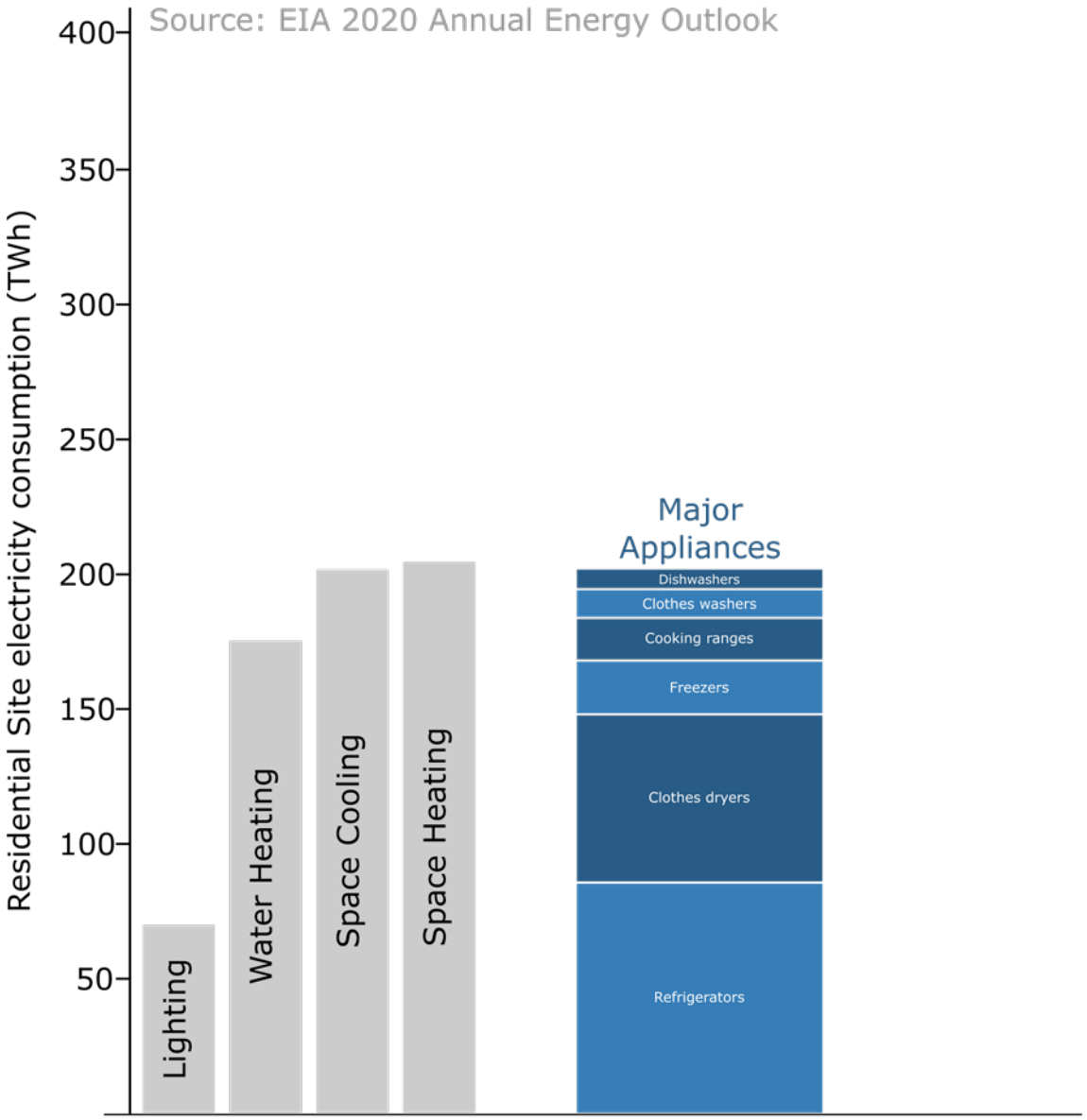
Building Energy Modeling

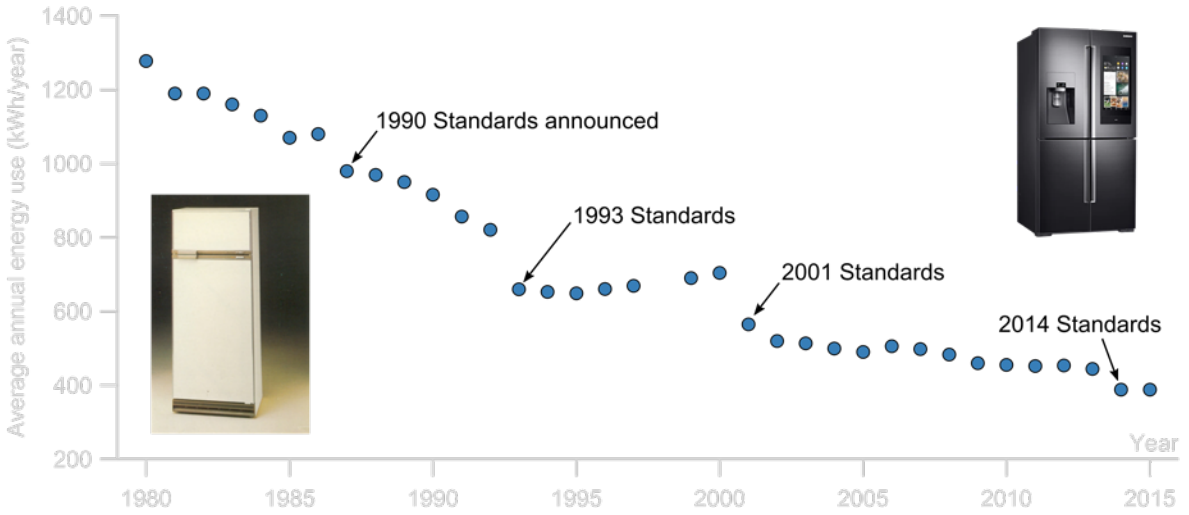
When isn't an electric load *miscellaneous*?



BEADS Decarb Toolbox

When isn't an electric load *miscellaneous*?





BEADS Decarb Toolbox

R&D for device-level efficiency
+ minimum efficiency standards

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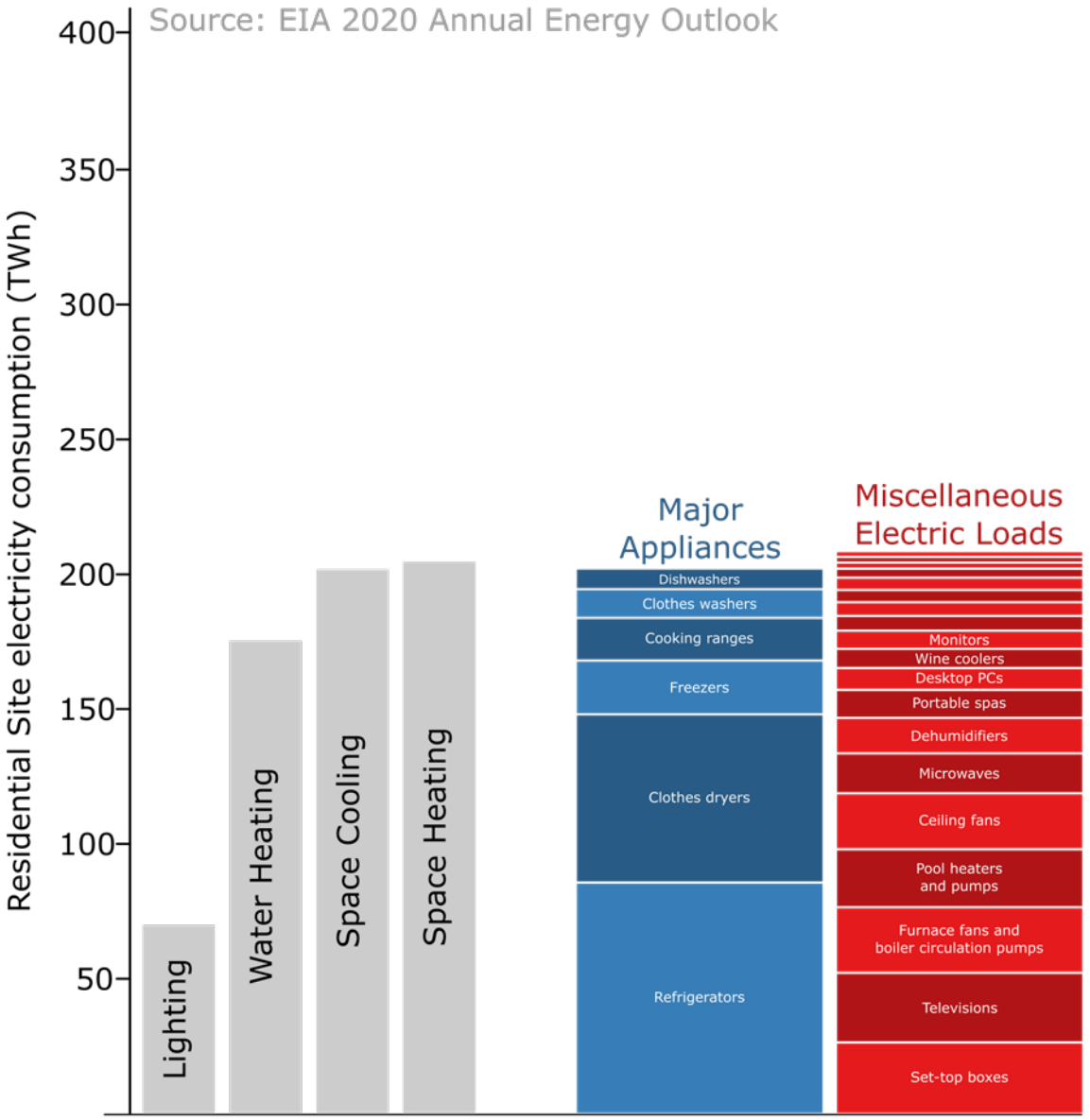

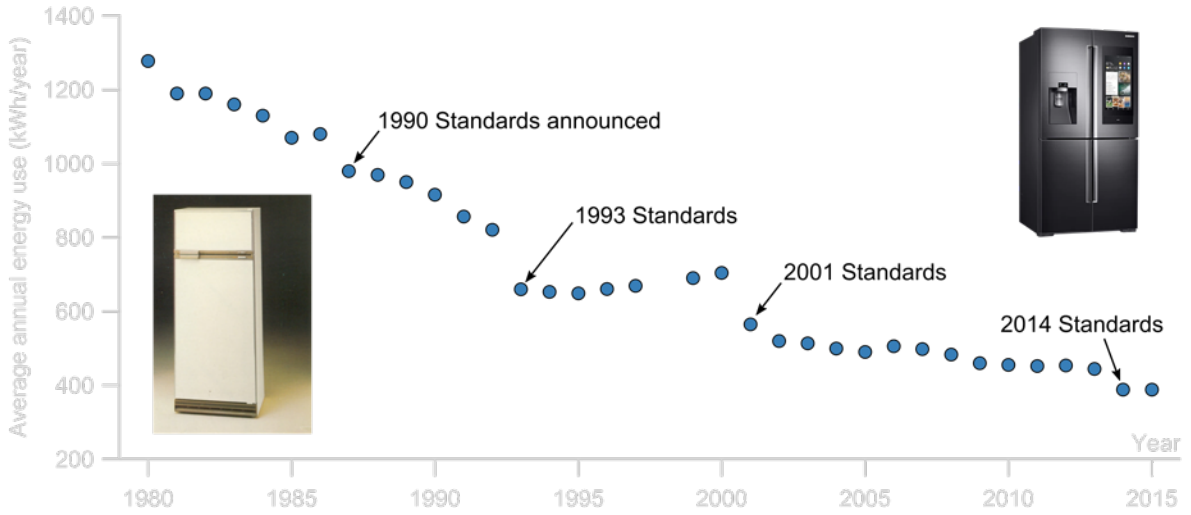

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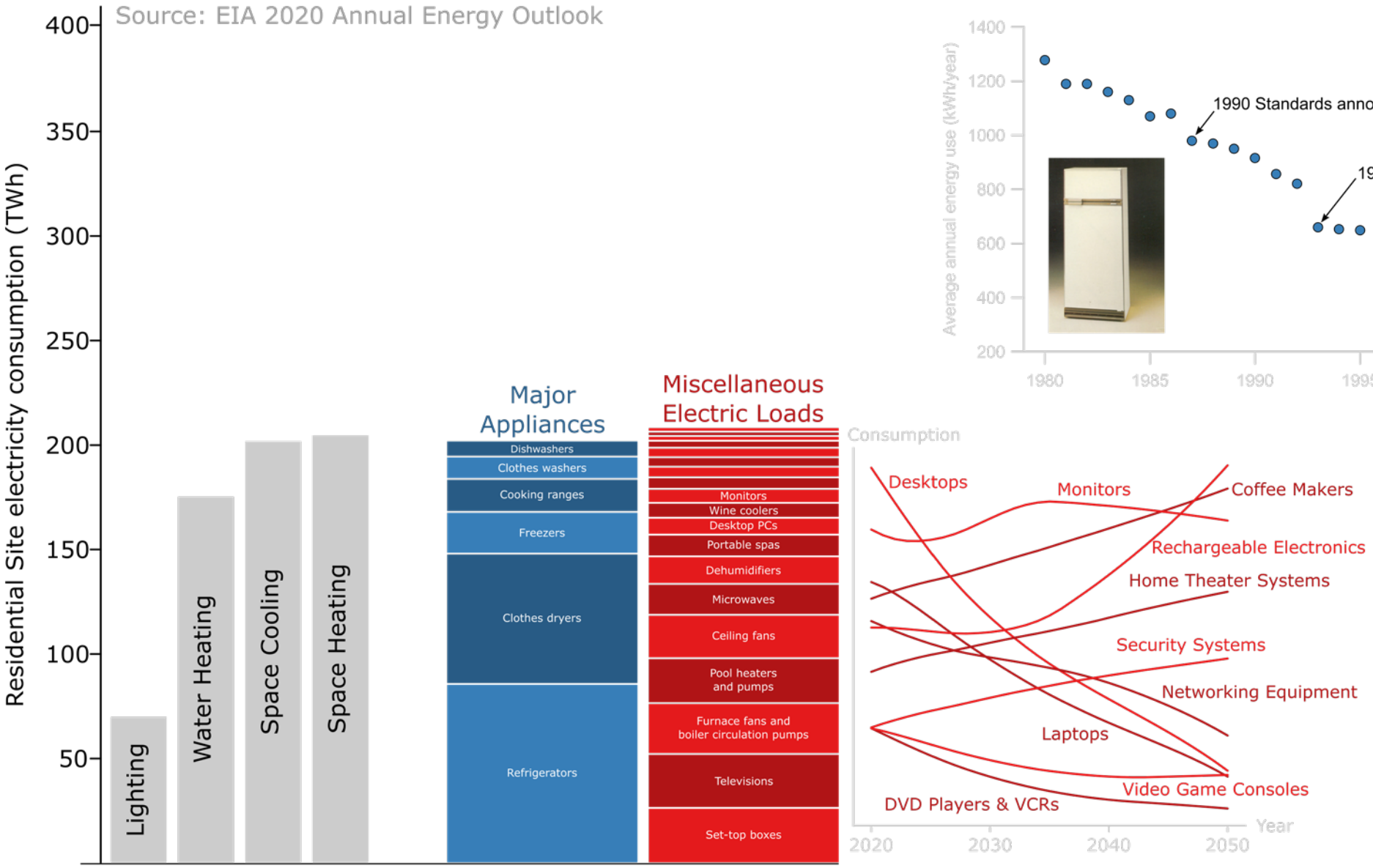
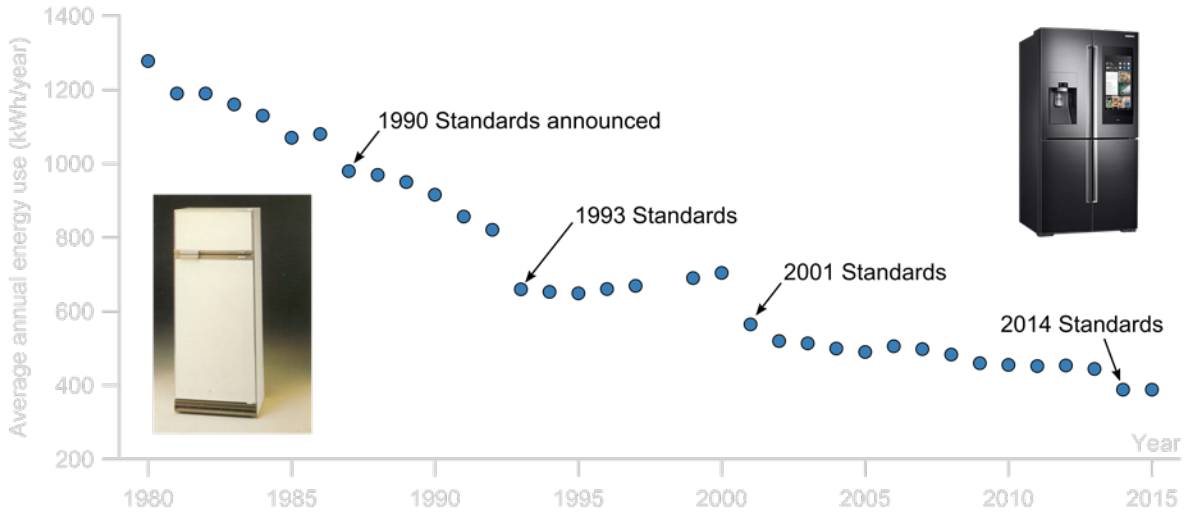


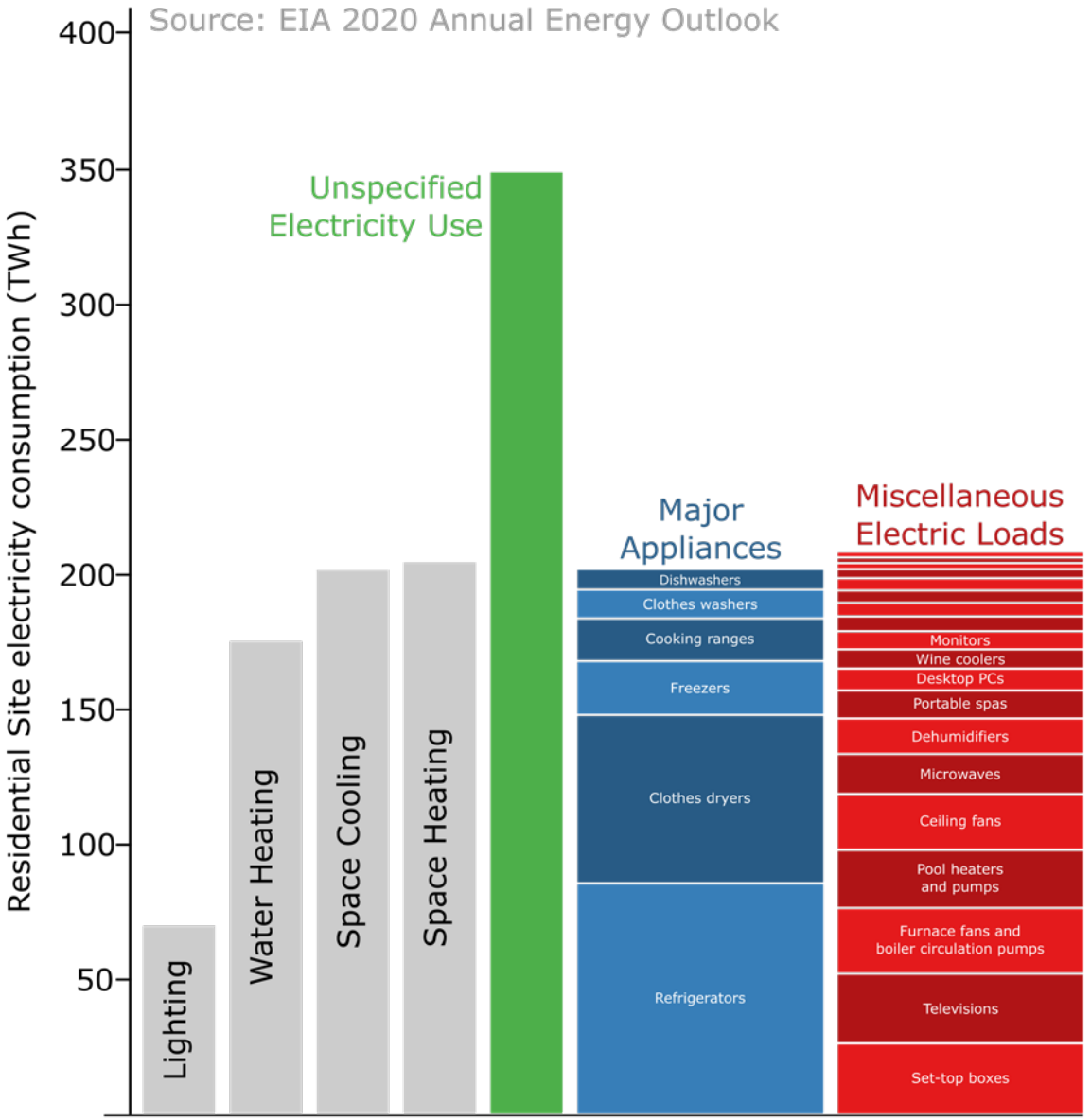


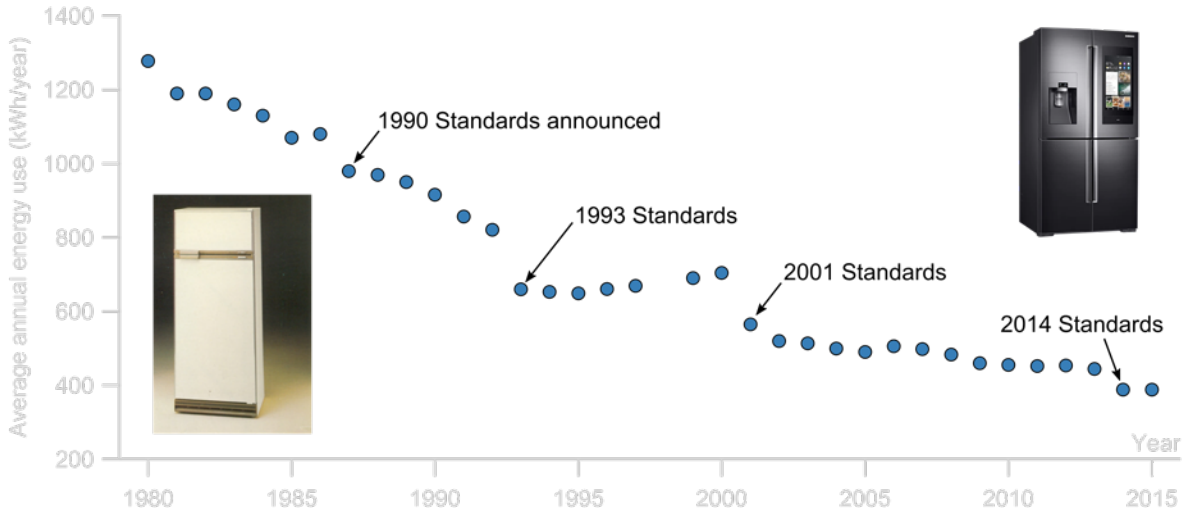
BEADS Decarb Toolbox

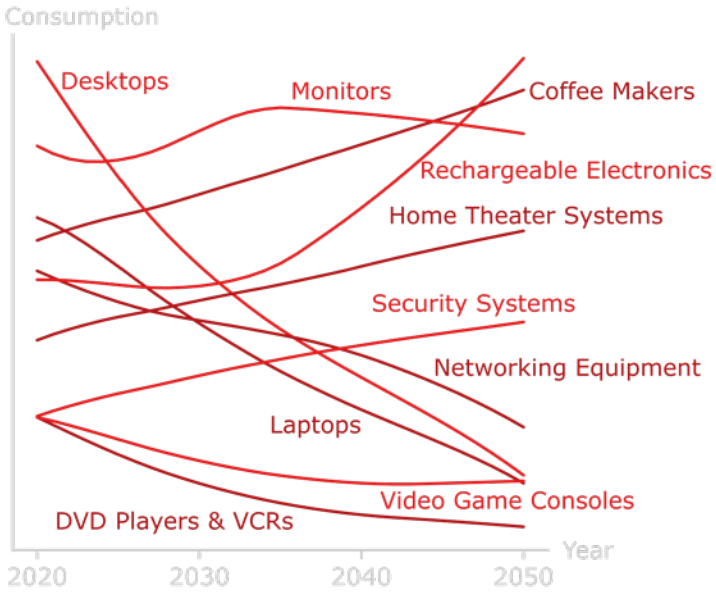
R&D for device-level efficiency + minimum efficiency standards

"Cross-cutting functionalities"

When isn't an electric load *miscellaneous*?







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R&D for device-level efficiency + minimum efficiency standards

"Cross-cutting functionalities"

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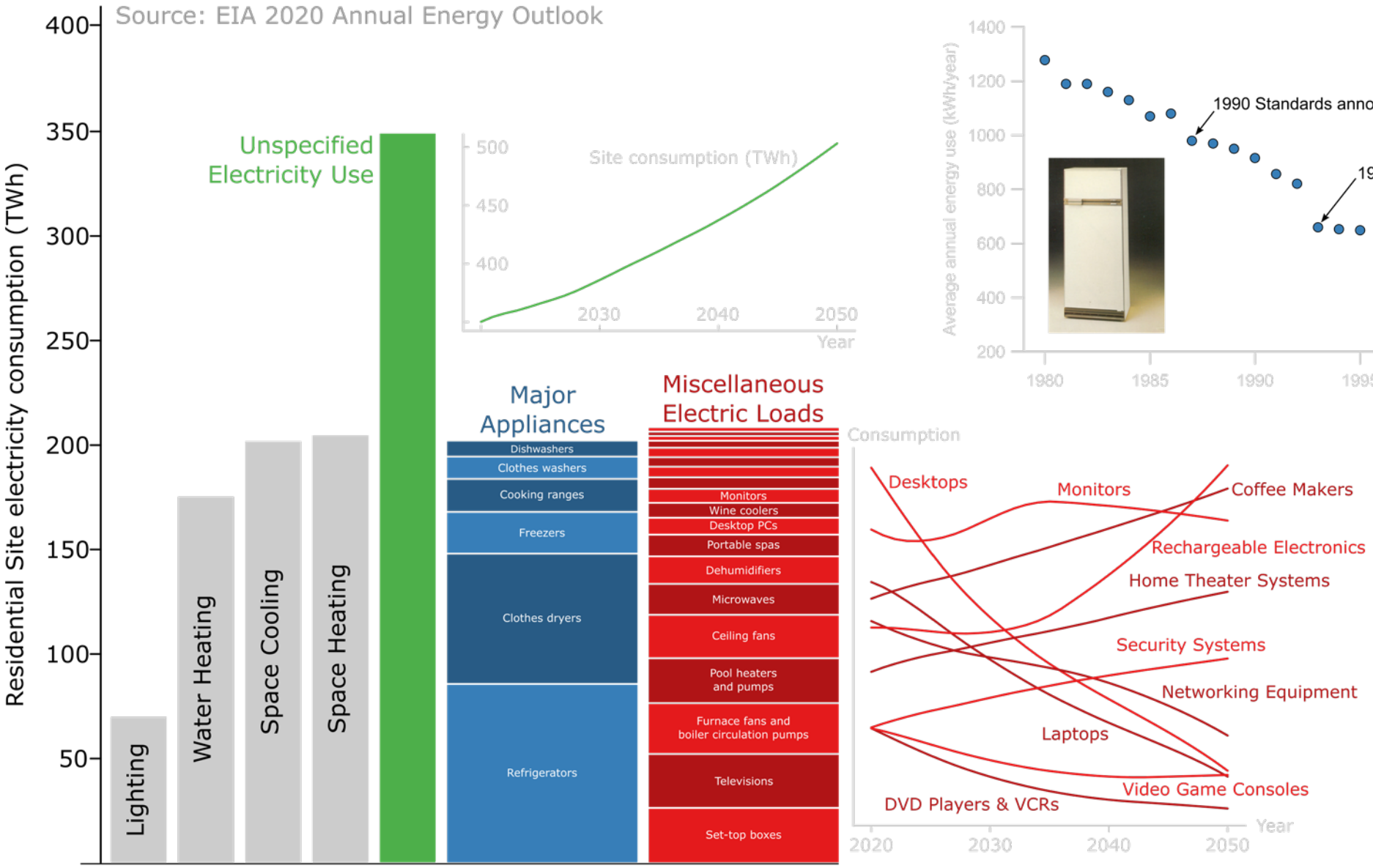
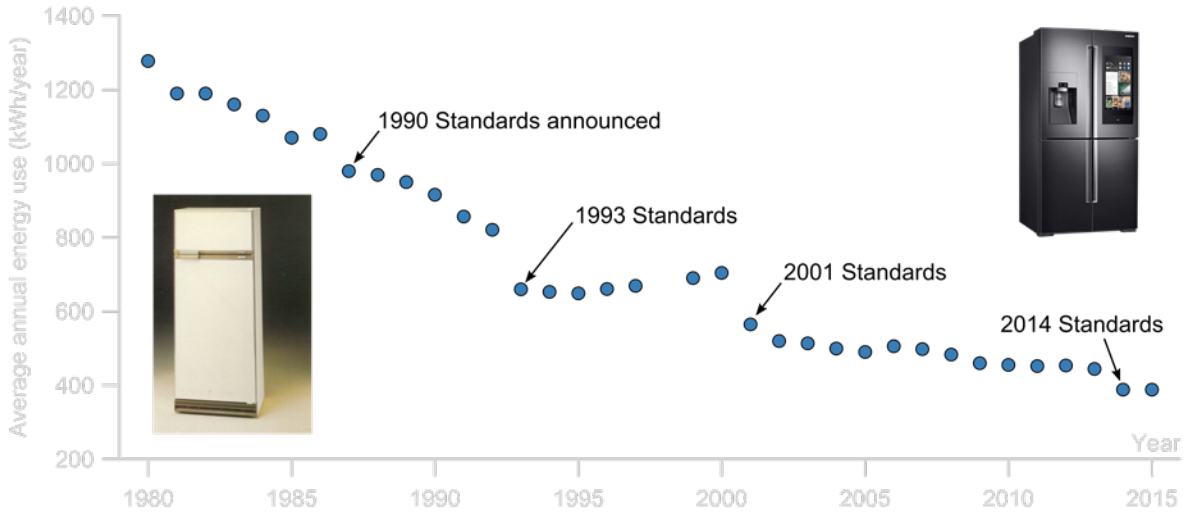




BEADS Decarb Toolbox

R&D for device-level efficiency + minimum efficiency standards

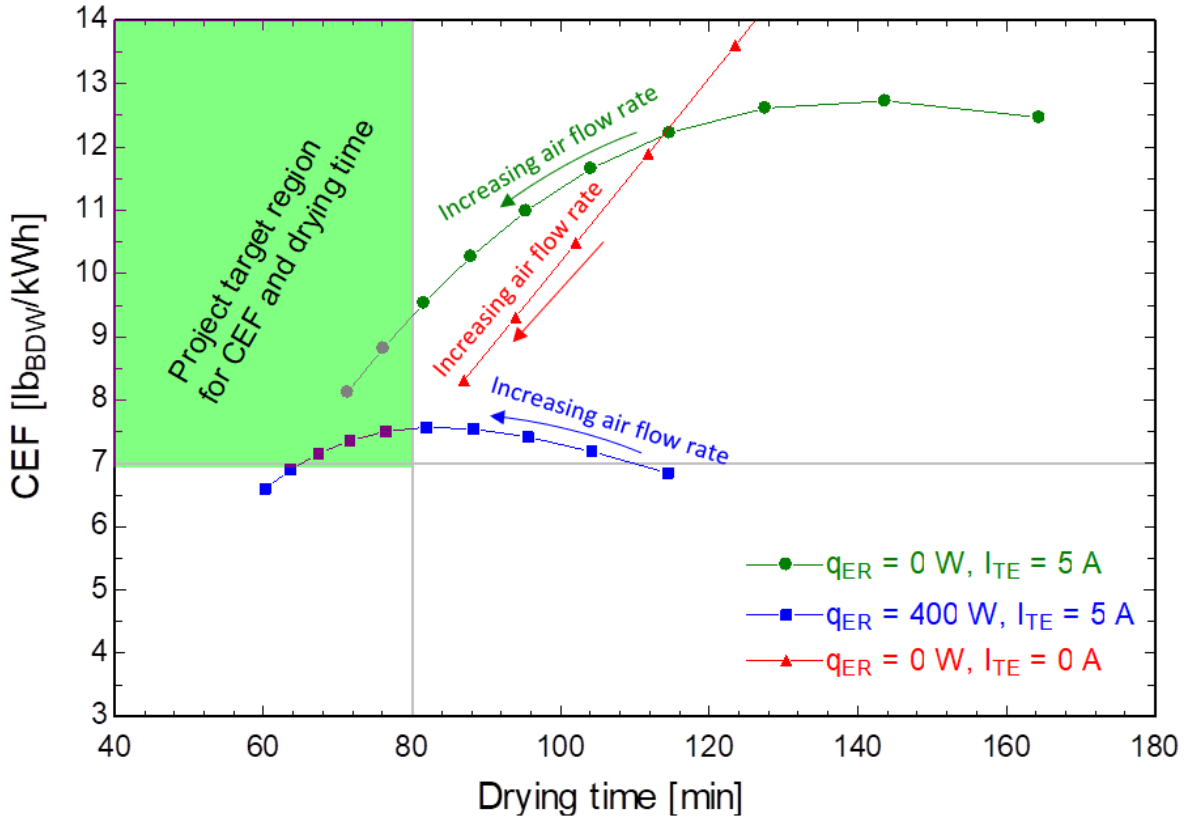
"Cross-cutting functionalities"

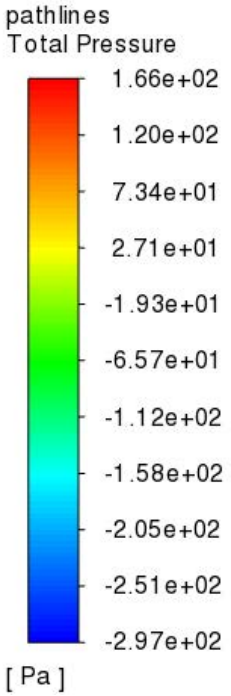
Information, data, analysis

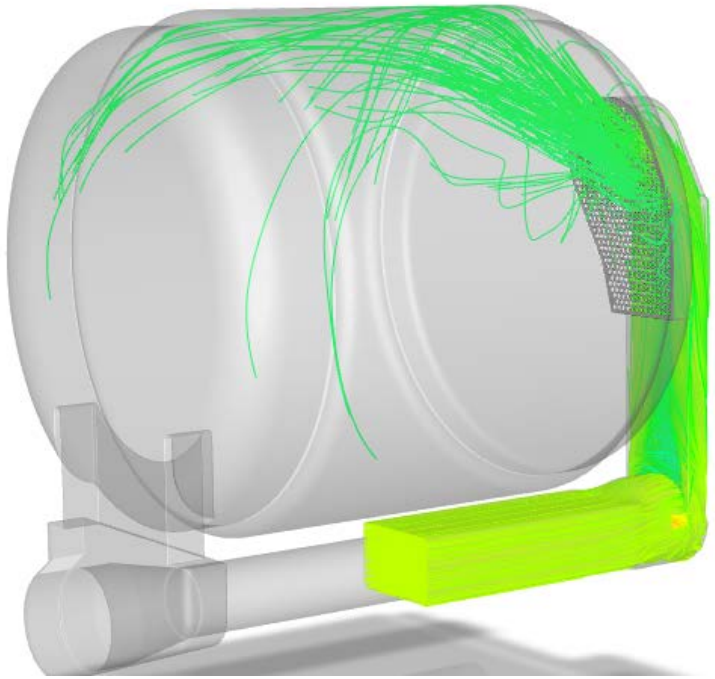
BEADS projects make electrification more viable

NEW EFFICIENCIES

More efficient MELs and major appliances can reduce the scale needed for renewable deployment







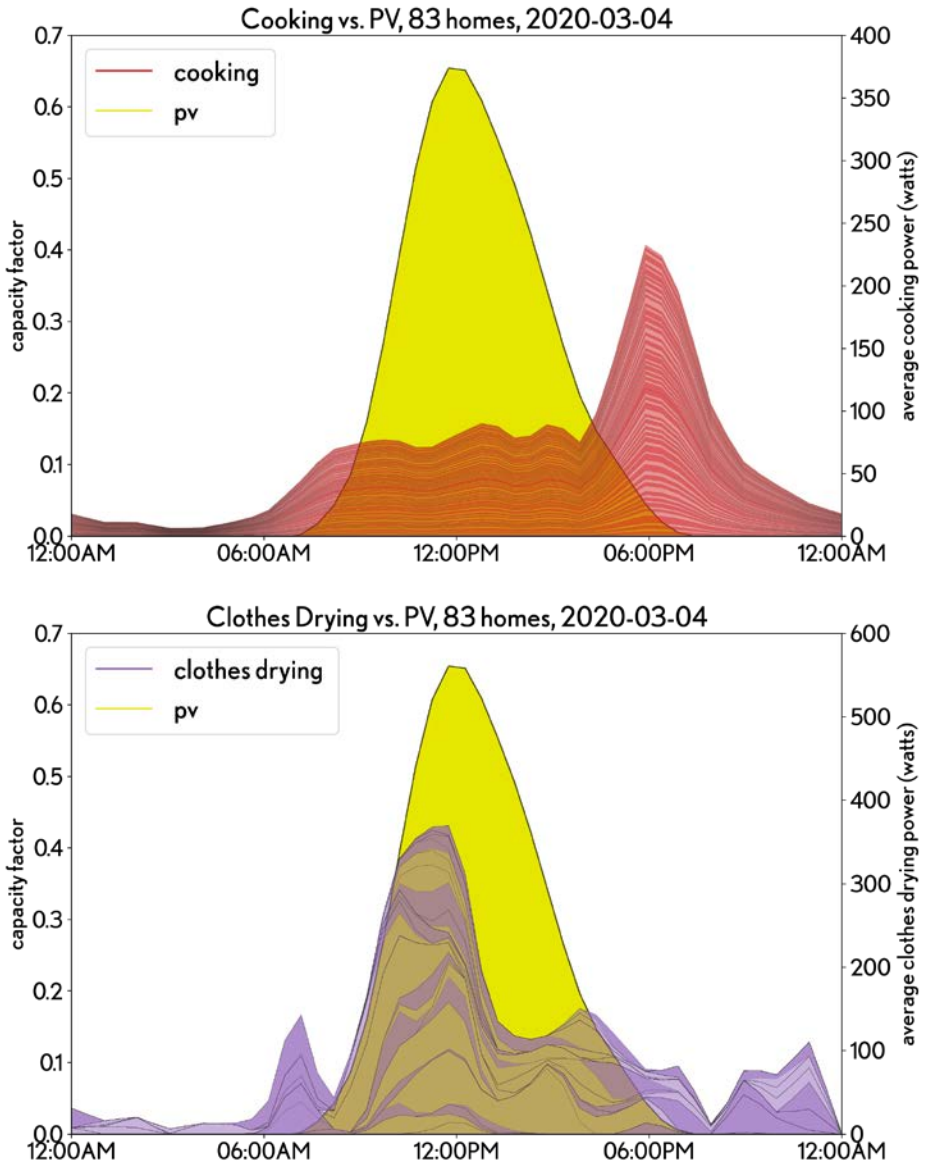
BEADS projects make electrification more viable

NEW EFFICIENCIES

More efficient MELs and major appliances can reduce the scale needed for renewable deployment

CAPACITY AND STORAGE

Storing and shifting transient electric loads can align demand with renewable supply, ensure grid stability, and potentially address panel capacity constraints



BEADS projects make electrification more viable

NEW EFFICIENCIES

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CAPACITY AND STORAGE

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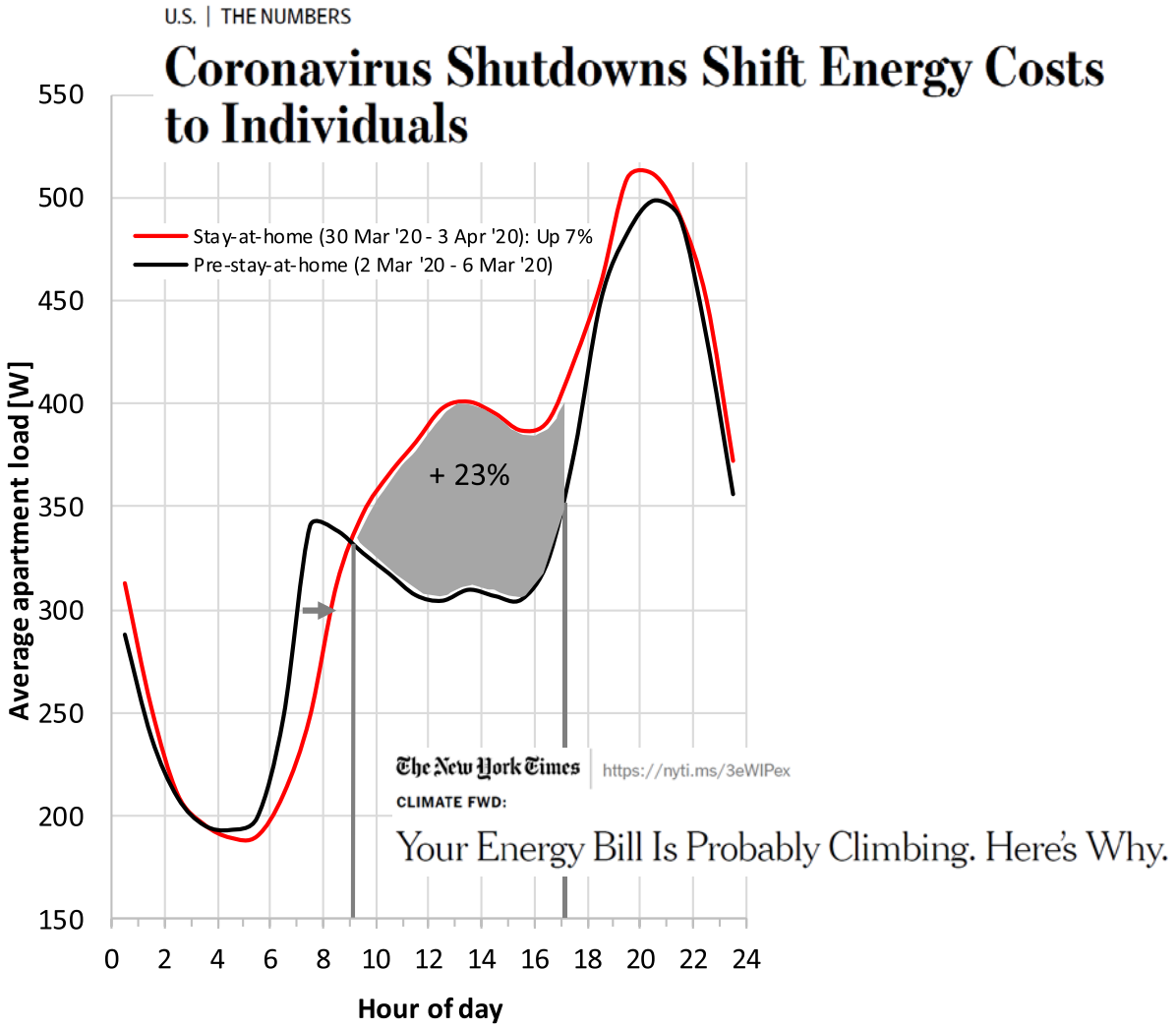
ELECTRICITY TRANSPARENCY

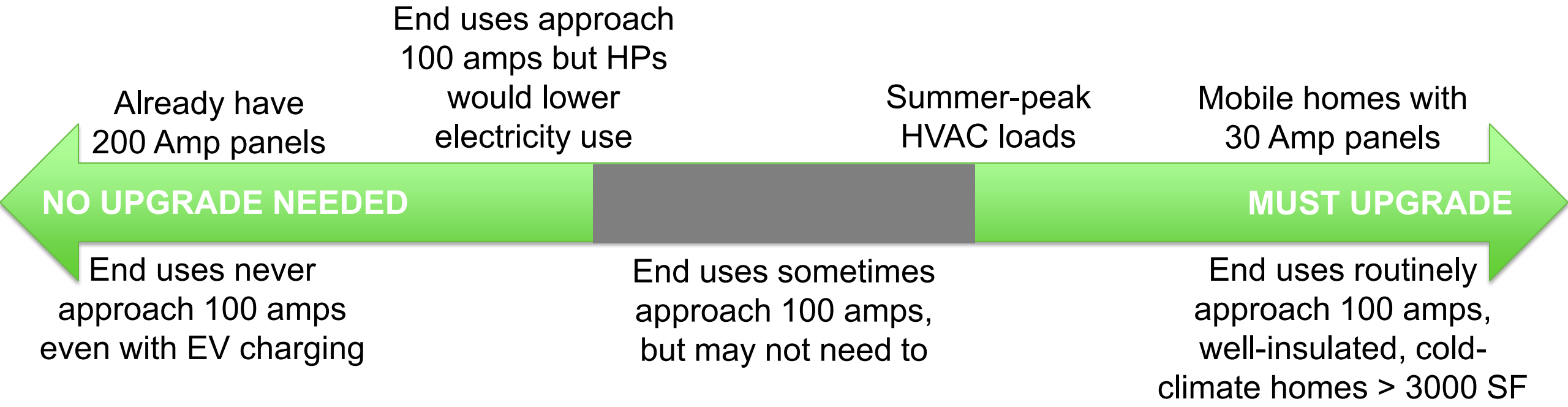
Sensing, load disaggregation, and self-reporting devices can provide insight for controls opportunities, DER management, heat pump sizing, fault detection, novel analyses, and can motivate decisions by building owners to lower electricity use



Active projects

Project	Performer	Efficiency	Capacity and Storage	Transparency
Improving energy efficiency of wireless communication circuitry in MELs	UVA	X		X
BE-SATED: building energy storage at the edges of demand	Otherlab		X	
Low-cost identification and monitoring of diverse MELs with Powerblade	UC-Berkeley			X
Reducing plug-load footprint through submetering and personalized feedback	Columbia			X
ICE: energy efficiency improvements in ice related processes	ORNL	X		
TECD: fast drying thermoelectric dryer	ORNL	X		
High-fidelity self-learning tool for residential load and load flexibility forecasting	Fraunhofer USA		X	X
Sensors impact evaluation and verification	ORNL/PNNL/NREL	X		X
Grid-interactive, resilient lighting and plug load management system using DC power	LBNL/Legrand	X	X	
Smart electrical panel-based HEMS	NREL/Span.io		X	
A behind-the-wall DC bus to power low-voltage DC products	LBNL/Power Integrations	X		
Standby loads characterization and website update	LBNL	X		X

Which homes need panel upgrades?



Working with 100 amp panels: the “gray area” tool box

- **Building enclosure improvements**
  - Air leakage sealing
  - Insulation
  - Windows
- **Appliance *power* efficiency (Kitchen, Laundry, HVAC, hot water)**
- **Controls**
  - Smart breakers
  - Automatic circuit sharers (Dryer/EV, Stove/EV, Cooking/WH, etc.)
    - Neocharge, simpleswitch, dryerbuddy
- **Home energy monitoring, load disaggregation, energy reporting (for proper HVAC sizing and identifying loads for reduction)**
- **Storage**
  - Whole building storage
  - Thermal storage
  - EV storage
  - Edge storage
- **Solar**
- **120 V heat pumps and HPWHs**
- **Ductless HVAC**
- **Heat recovery ventilation, energy recovery ventilation**

Power conversion as wasted electricity

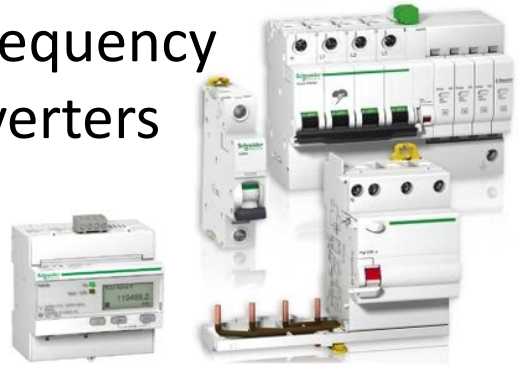
Solar inverters

Power supplies

LED drivers

Battery inverters

Variable frequency drive inverters



AC meters, breakers

Chargers

Power conversion as electronic waste

Solar inverters

Power supplies

LED drivers

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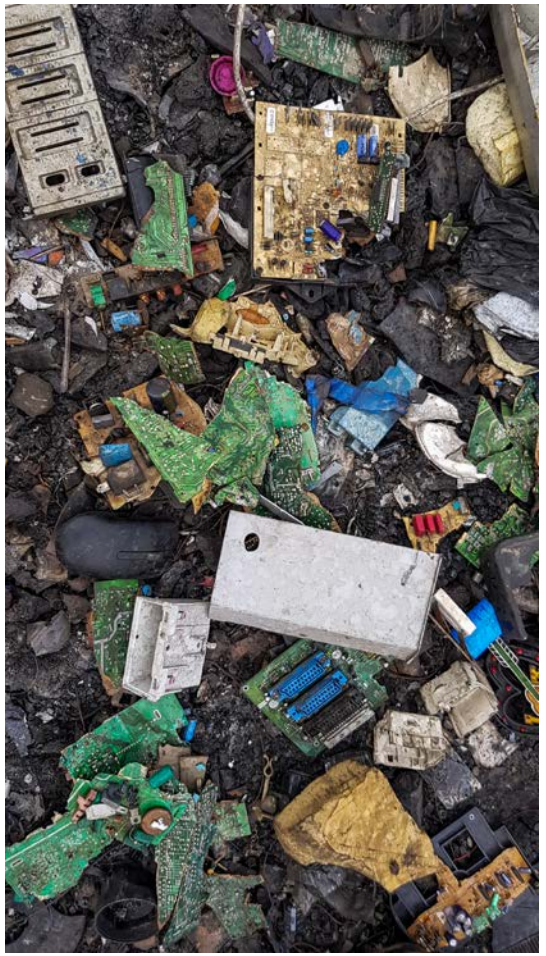
Variable frequency drive inverters

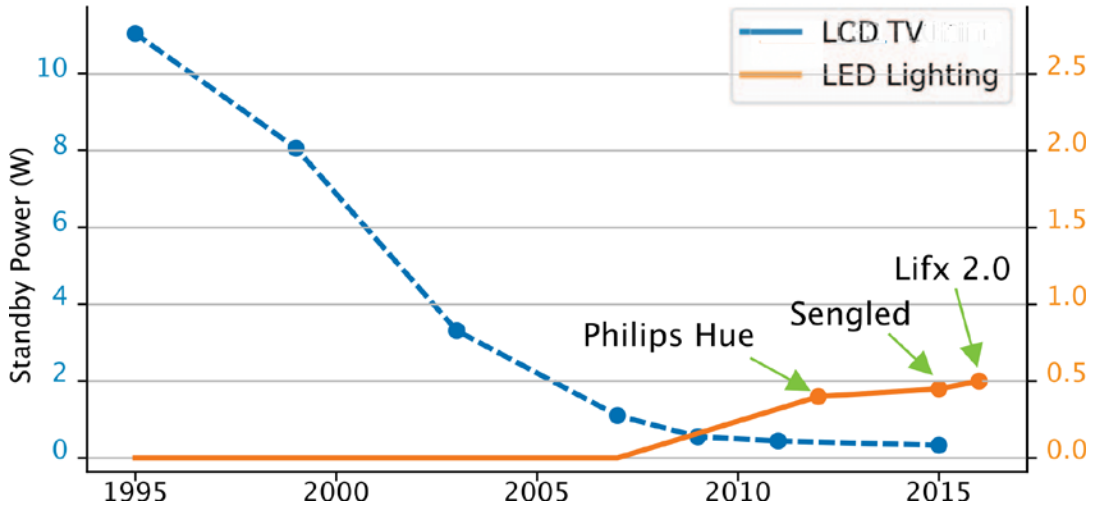
AC meters, breakers

Chargers

NEEDLESS WASTE

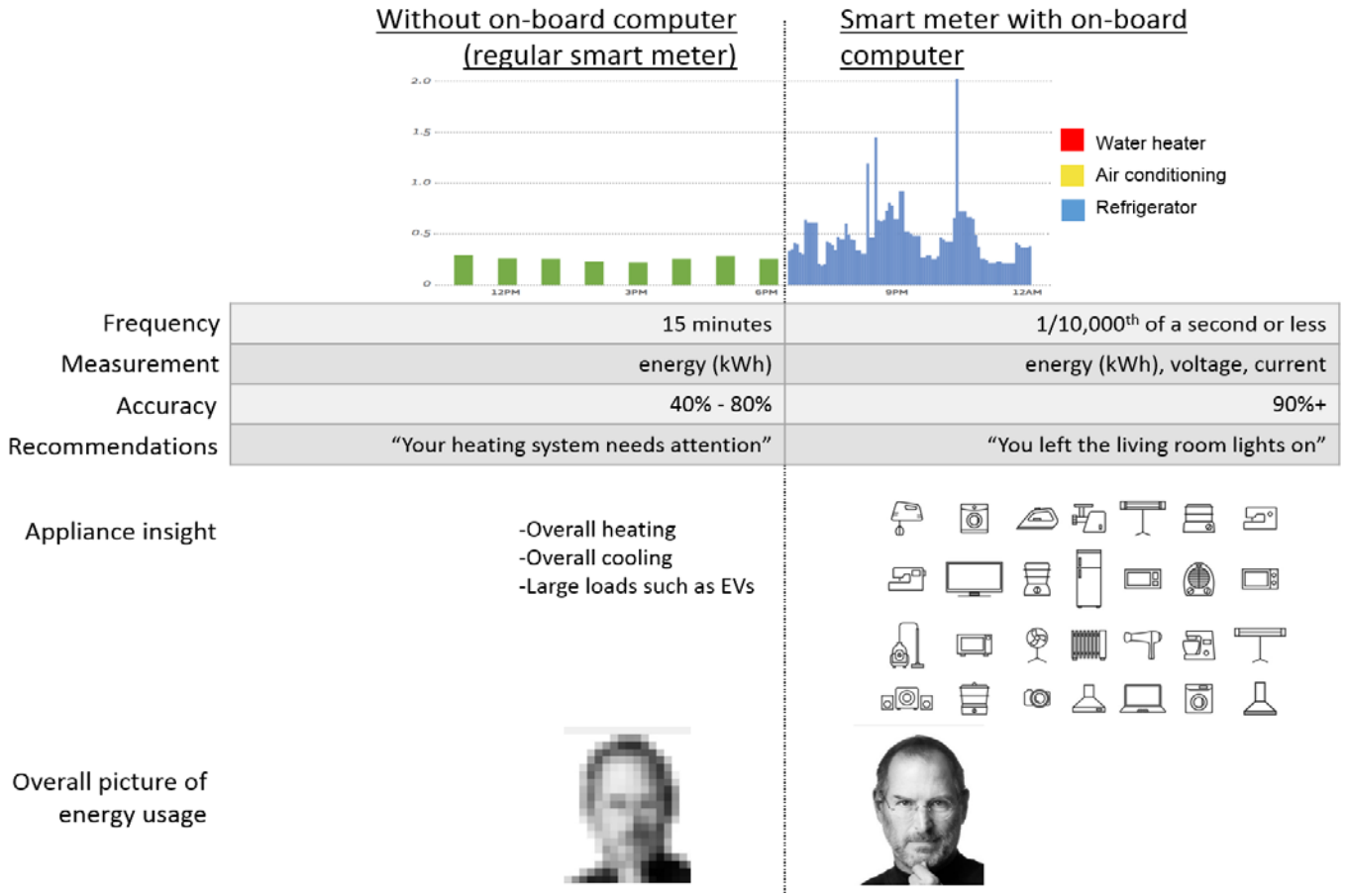


Connected devices: *in principle*, an opportunity to save energy



Next-generation load disaggregation

- ML data processing of high-res samples
- Smart meter on-board computing
- BEADS opportunities
  - NILM standards/credentialing
  - Field validations
  - High-resolution datasets
  - Self-reporting/teaching devices



Credit: Michael Murray, Mission Data