Demand-Side Electrification Constraints and Emerging Technology Solutions

U.S. DEPARTMENT OF ENERGY
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

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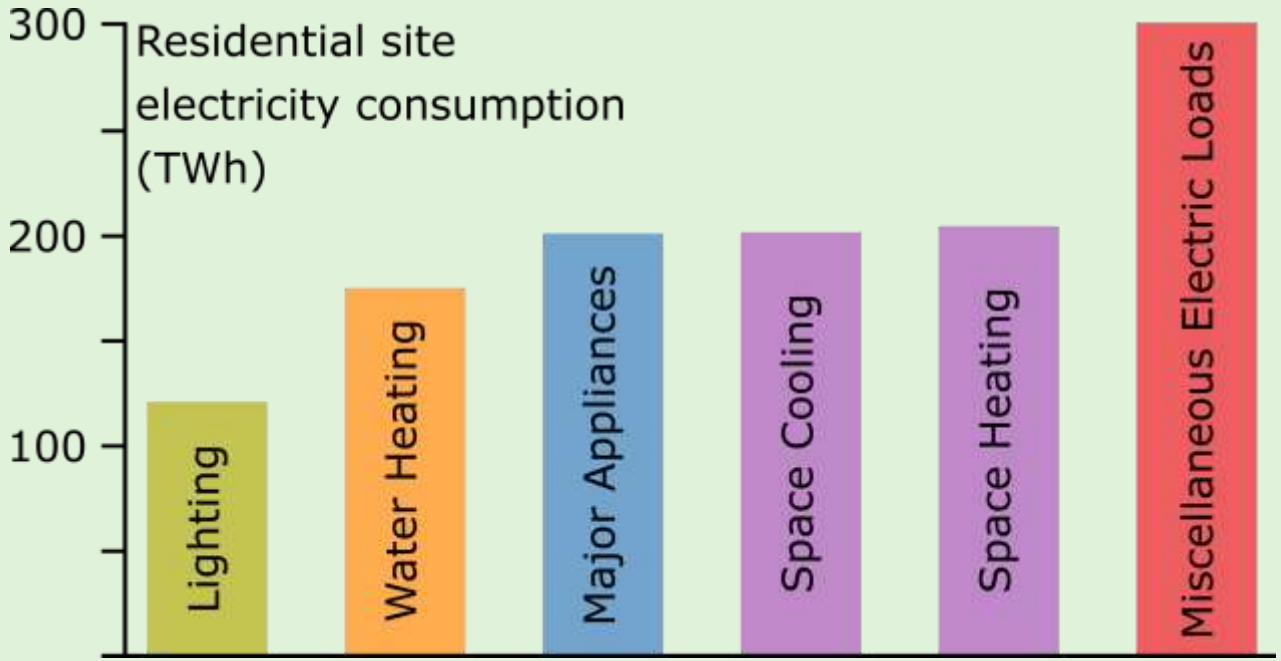
U.S. DOE Building Technologies Office (BTO)



Developing intuition for the demand-side scale of electrification

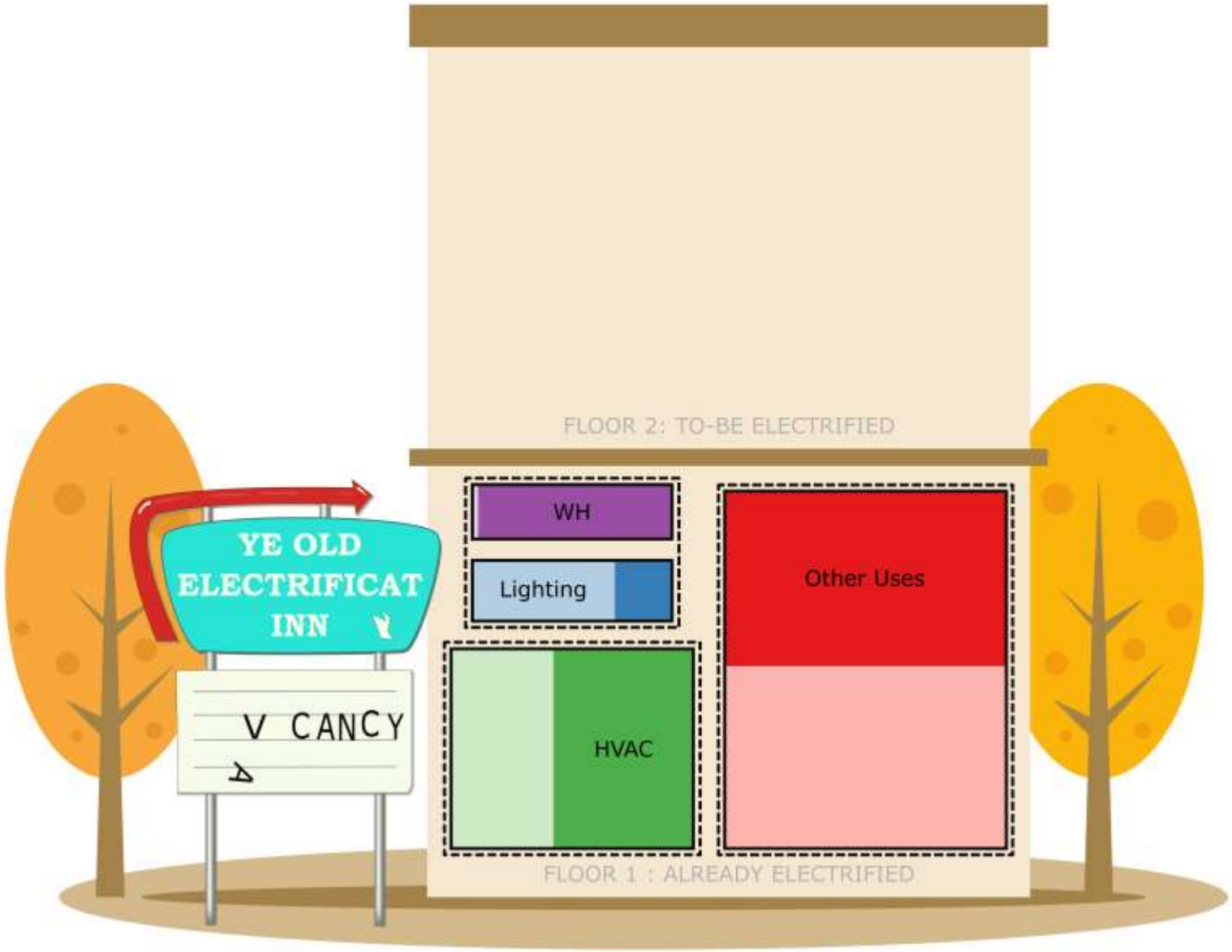
Visualizing building loads

Visualizing building loads

Site Energy Consumption (2022, projected)

Source: EIA 2021 Annual Energy Outlook

Residential Buildings (dark fill)
Commercial Buildings (light fill)



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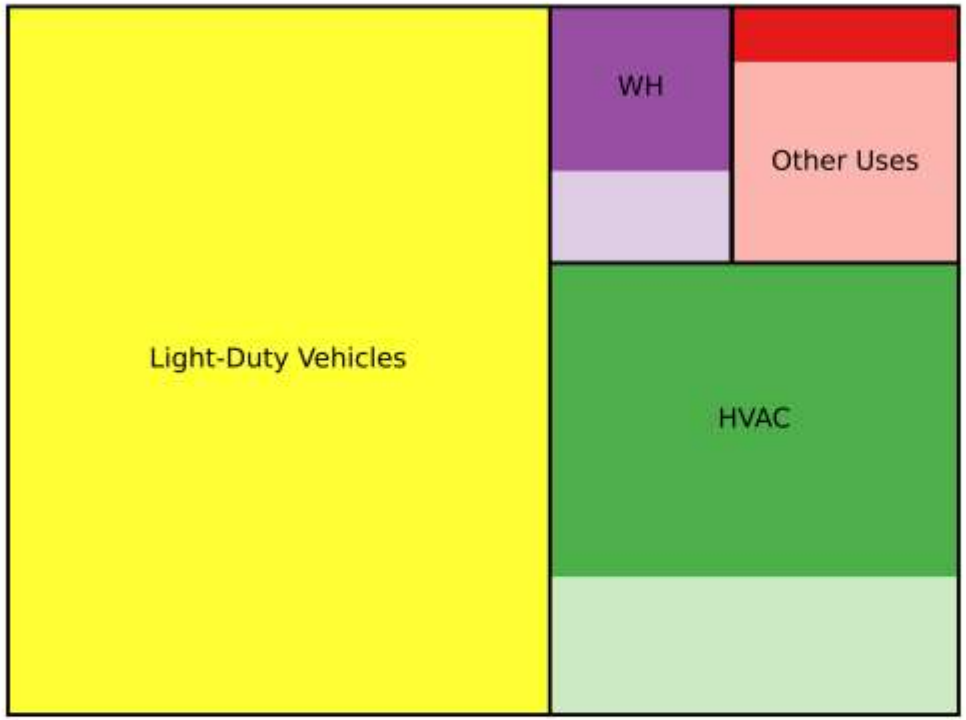

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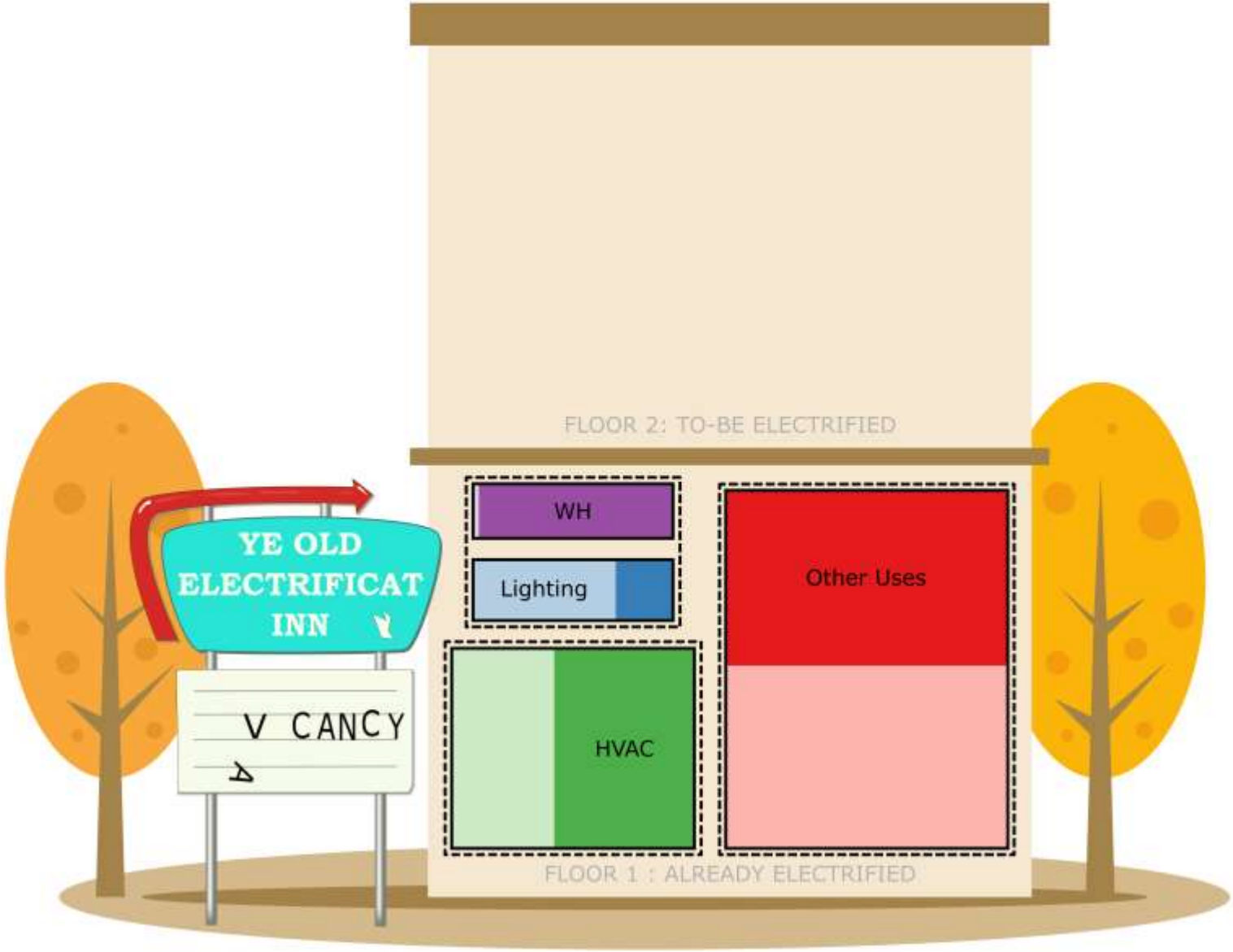

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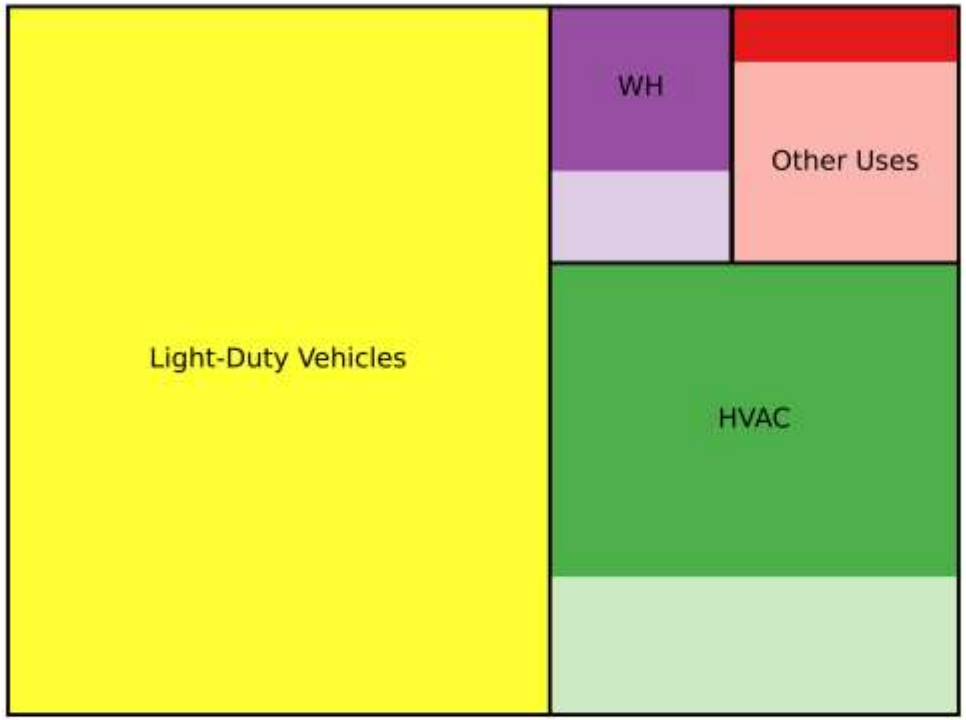

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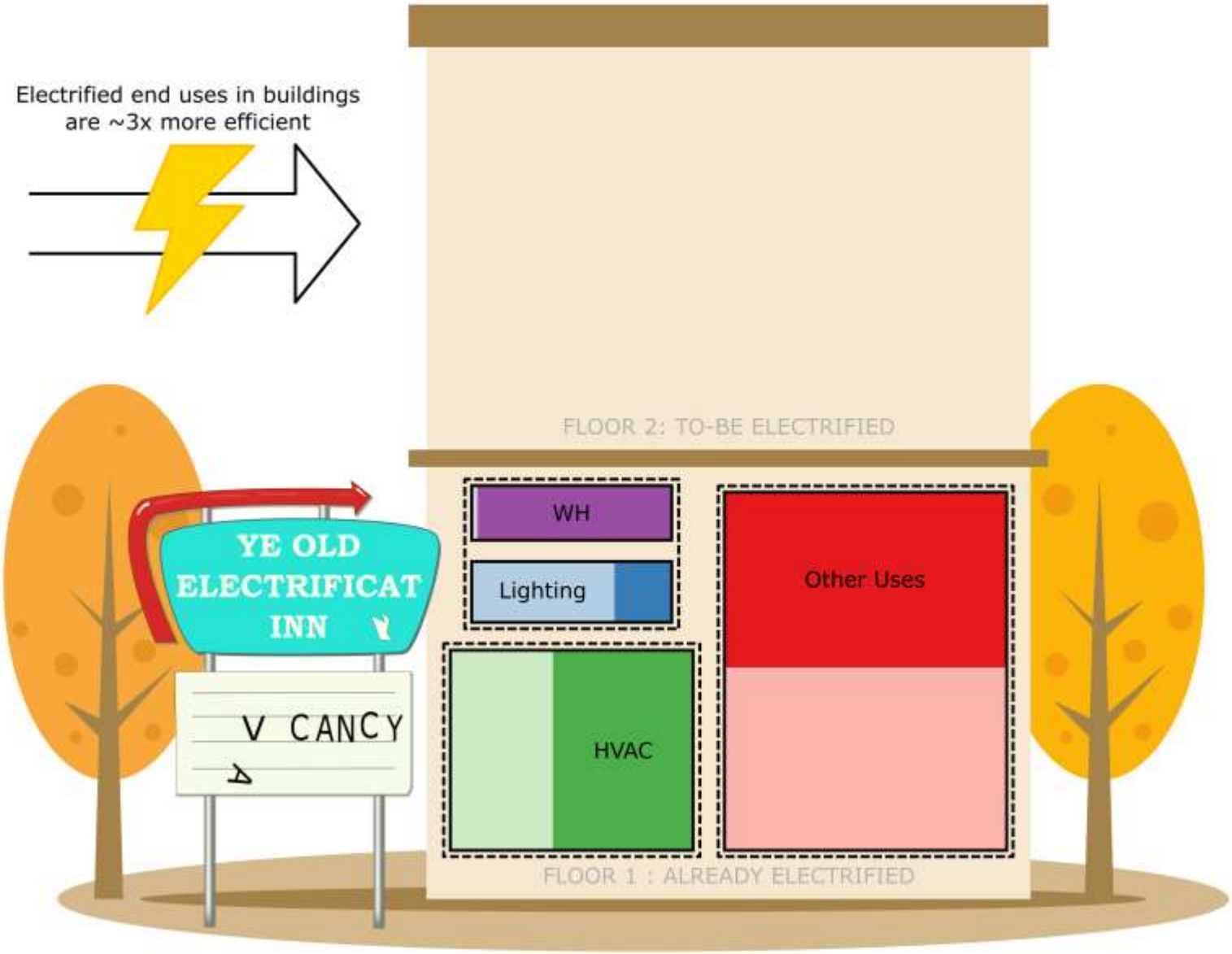
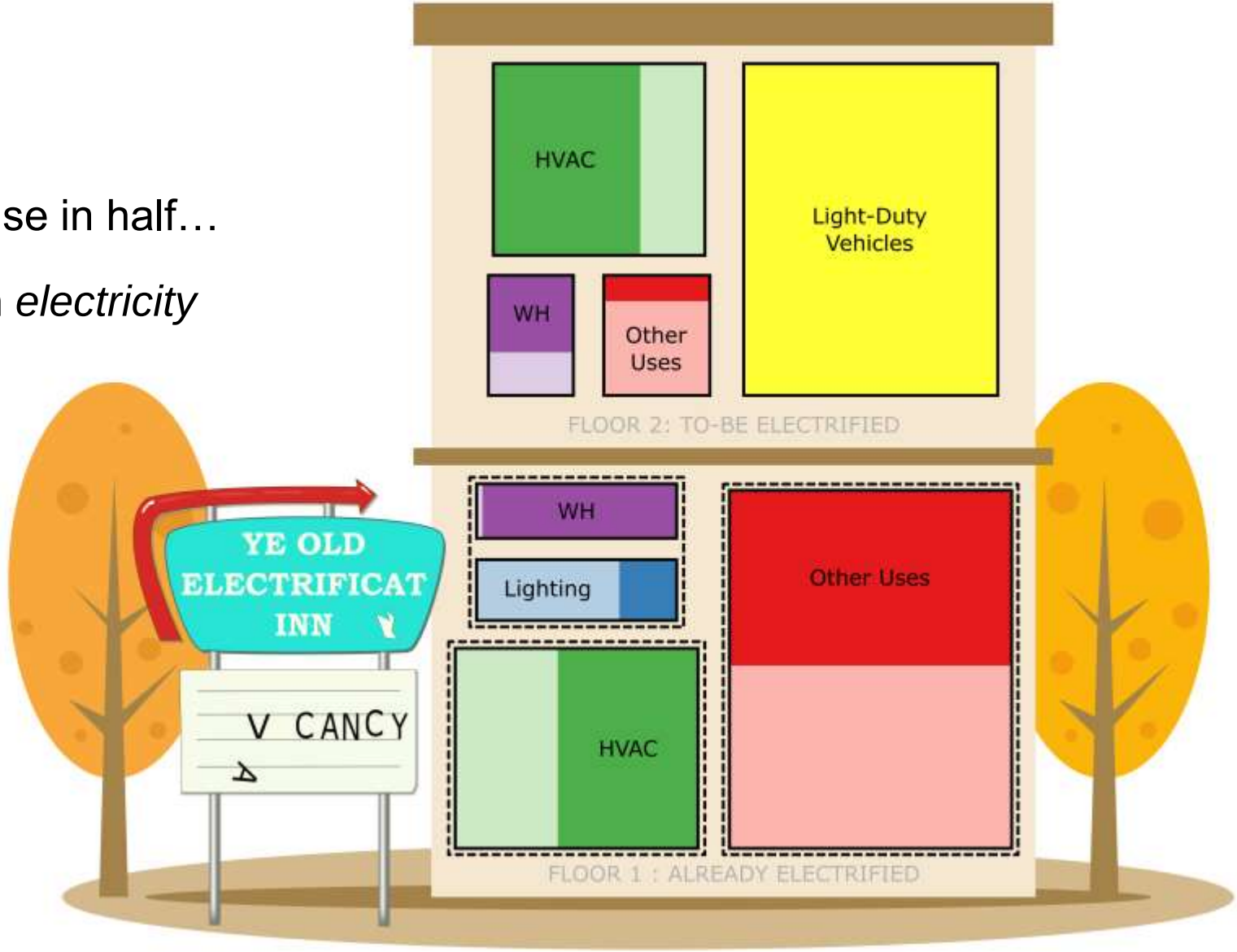


Visualizing building loads

Bringing it all together…

Electrification can cut *energy* use in half…

…but can require ~2x as much *electricity*



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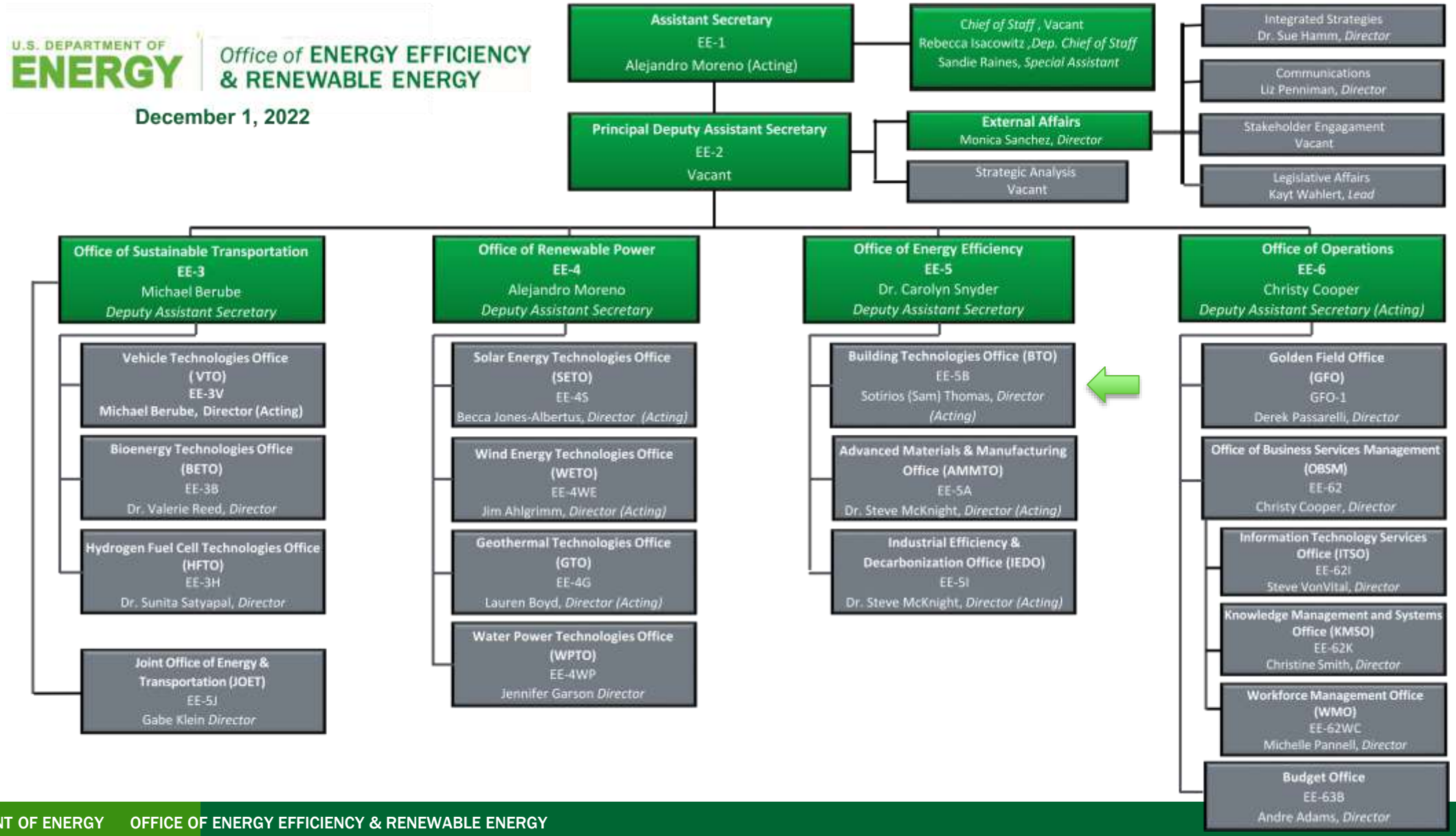
The Building Technologies Office (BTO)

BTO is one of many EERE technology offices



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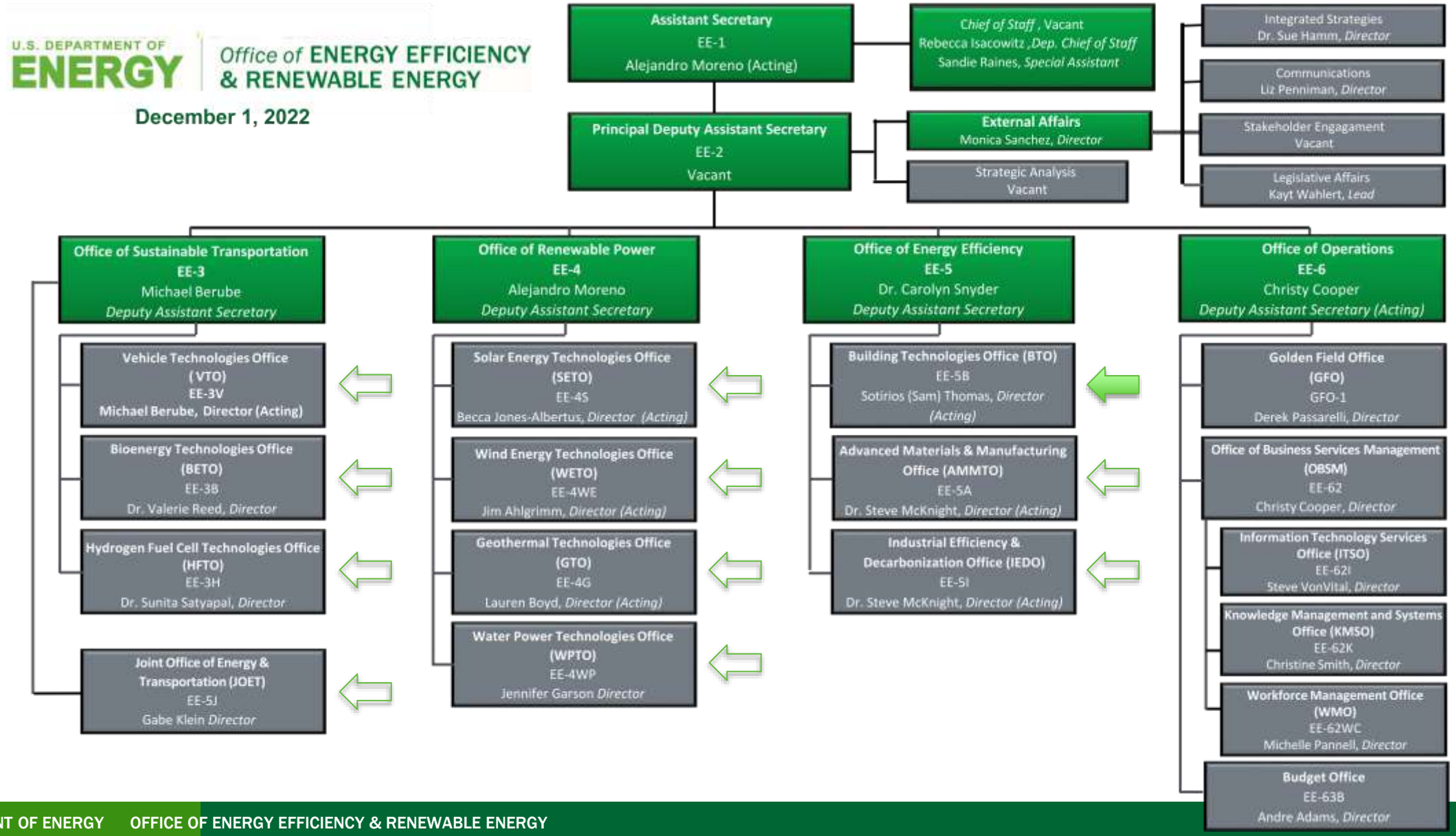


The Building Technologies Office approach

BTO invests in energy efficiency & related technologies that make homes and buildings more affordable and comfortable, and make the US more sustainable, secure and prosperous. Activities include:

R&D

Pre-competitive, early-stage investment in next-generation technologies

Integration

Technology validation, field & lab testing, metrics, market integration

Codes & Standards

Whole building & equipment standards technical analysis, test procedures, regulations

Energy-Storage Equipped Appliances

Embedding batteries in appliances unlocks multiple benefits

Reduced electrical work: No need to run new circuits, 120-V outlets already in most kitchens to power oven clock
Cheaper storage: Centralized home batteries can be ~$1000/kWh installed vs. ESE appliances at ~$100/kWh factory-installed
Resilience: Cook during blackouts, including auxilary outlet for other appliances or devices
Load shifting: Battery can charge during off-peak hours, bidirectional models in development, aggregation possible
IRA incentives: 30% tax credit for battery storage, possible rebate for induction, local incentives in some areas
No buzzing! Induction coils driven by direct current

Clothes Dryers 20MM

Tank Hot Water Heaters 57MM

Instant Hot Water Heaters 8MM

Ranges 45MM

Service Addressable: difficult to electrify homes, 22.5MM
Market Value: $135 Billion at $6000 per/ home

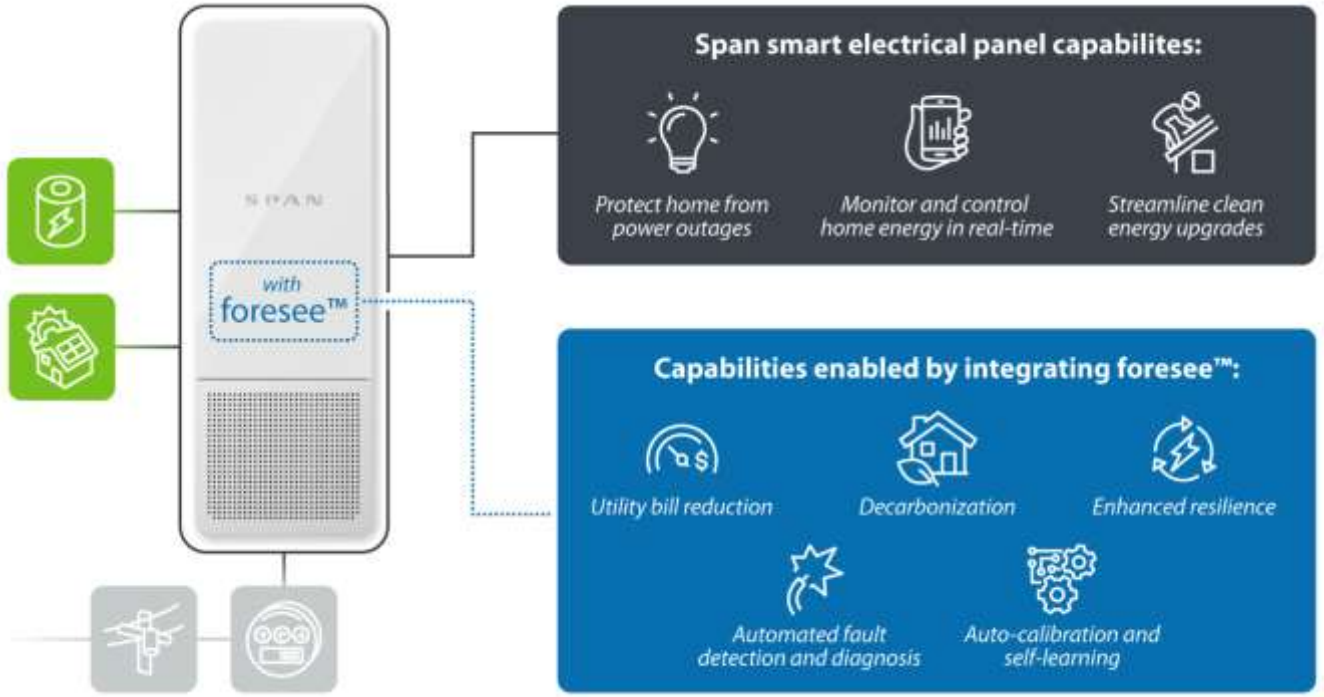
Smarter Smart Panels

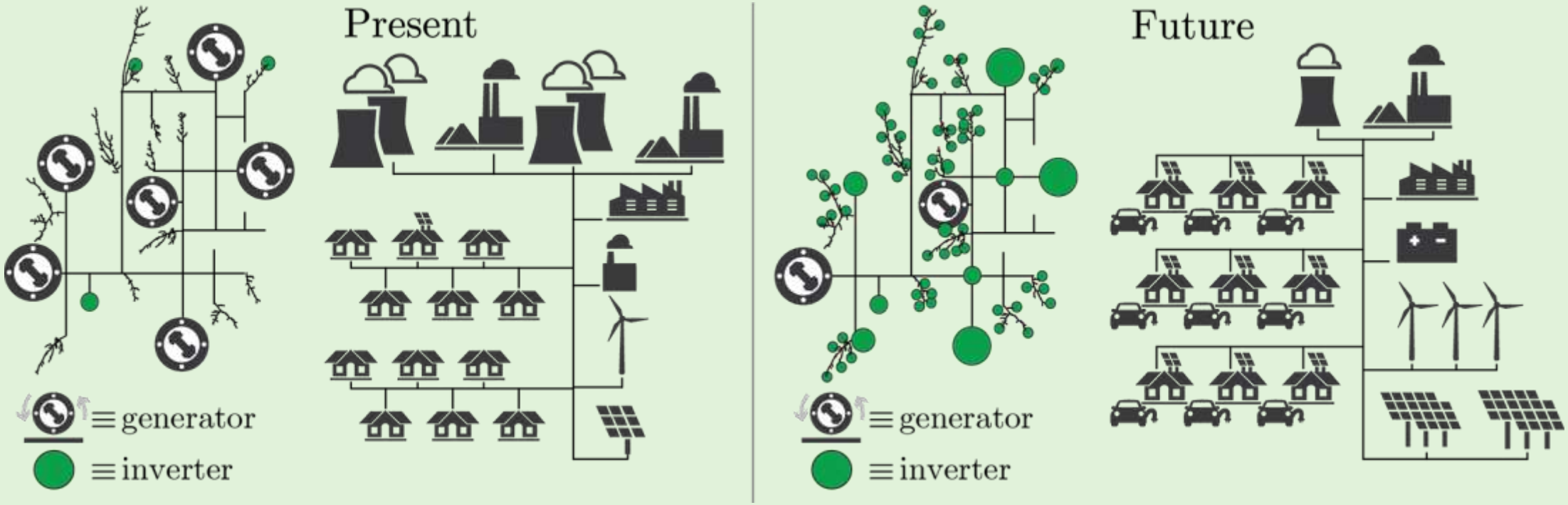
NREL and Span.io are integrating HEMS with their smart panel

Building occupants: A fully integrated, one-stop solution for autonomous building energy management. Building occupants will benefit from lowered utility bills, improved thermal comfort, and enhanced resilience during electric grid outages.

Electric utilities: Help the electric utilities improve demand flexibility via load shifting or curtailment, avoid distribution system upgrades by limiting whole-home instantaneous demand, and mitigate the potential overvoltage issues by self-consuming PV.

Societal benefits: Reduce operational carbon emissions by aligning the building load with time periods when the grid carbon intensities are low and avoiding electricity import from the grid when the grid carbon intensities are high.

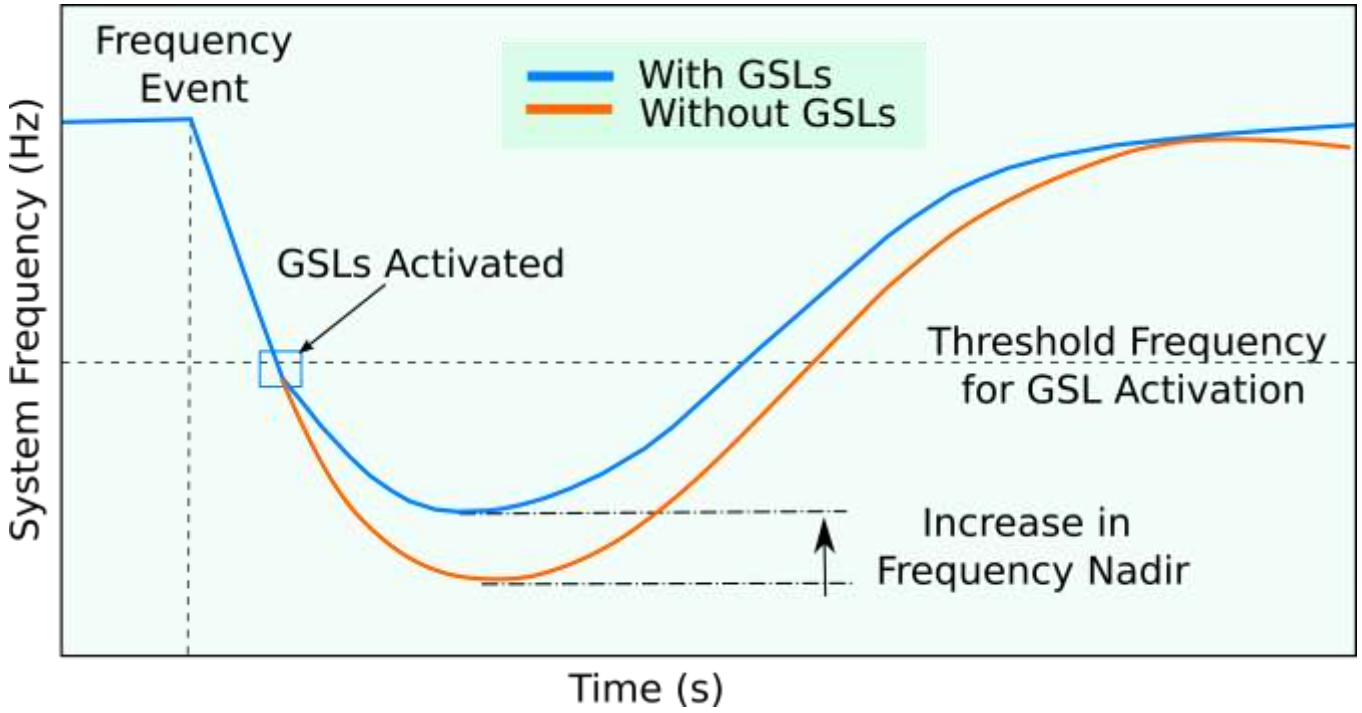




Grid-Supportive Loads

Inverter-based loads can provide grid support in aggregate

Types	Synchronous Machines	IBRs
Generators	Fossil Fuel, Hydro, Nuclear	Solar PV, Wind Batteries
Loads	Synchronous Motors Induction Motors	EV Chargers Power Electronic Loads Variable Frequency Drives



Cost-Benefit Analysis for GSLs

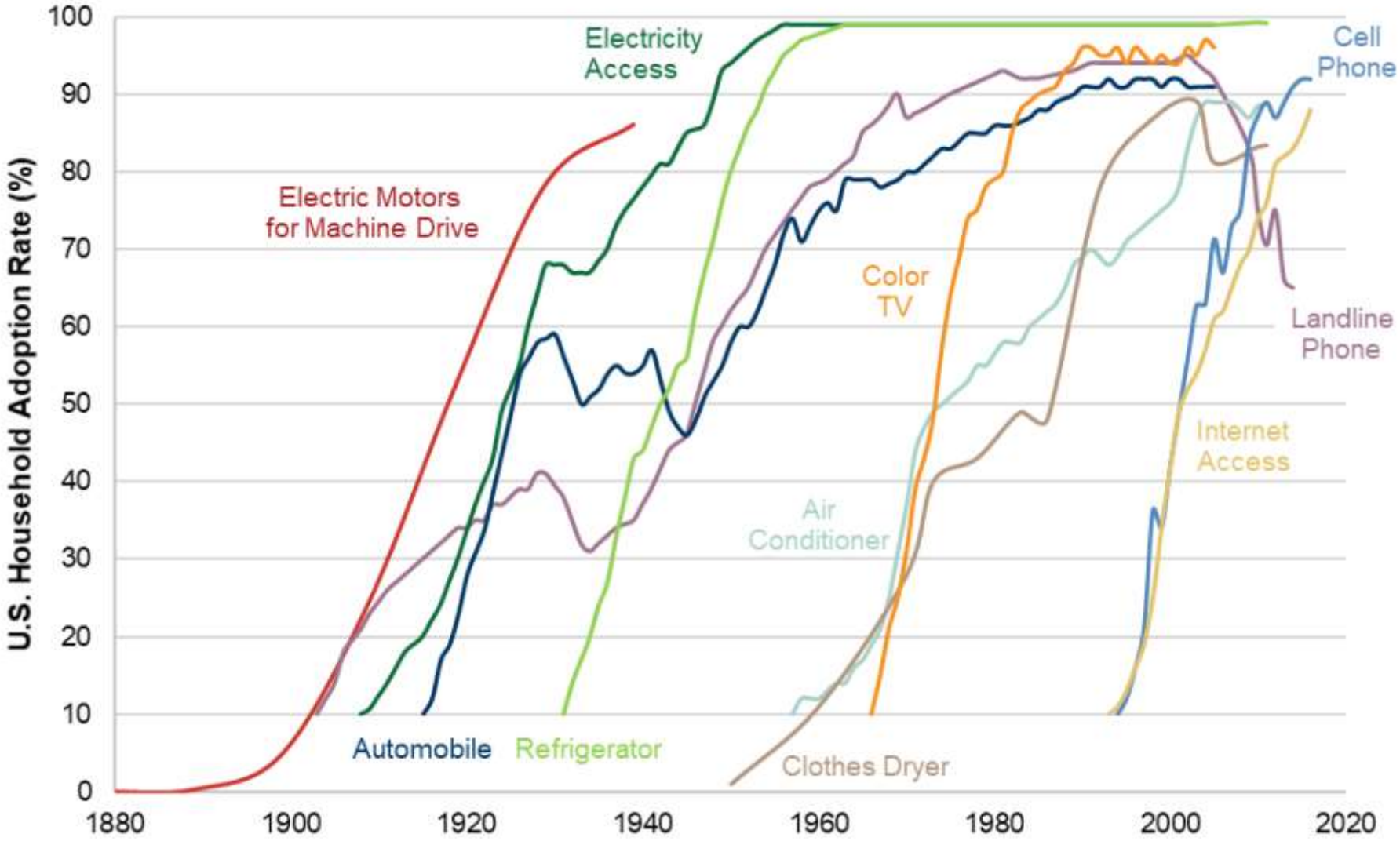
COST-BENEFIT ANALYSIS OF THE GSLS WITH THE MINIMUM INCENTIVES OF $1/MWH AND THE AVERAGE LIFE OF 10 YEARS

GSLs Cost-benefit ($)	Refrigerator	L2 EV	L3 EV
Average Cost	$0.52	$0.52	$3.5
Benefit with minimum power	$4.26	$10.70	$30.22
Net-benefit with minimum power	$3.74	$10.18	$26.72
Benefit with average power	$4.81	$15.65	$53.00
Net-benefit with average power	$4.29	$15.14	$49.50

COST-BENEFIT ANALYSIS OF THE GSLS WITH THE MAXIMUM INCENTIVES OF $8/MWH AND THE AVERAGE LIFE OF 10 YEARS

GSLs Cost-benefit ($)	Refrigerator	L2 EV	L3 EV
Average Cost	$0.52	$0.52	$3.5
Benefit with Minimum Power	$34.08	$85.63	$241.76
Net-benefit with Minimum Power	$33.57	$85.11	$238.26
Benefit with Average Power	$38.45	$125.24	$423.96
Net-benefit with Average Power	$37.93	$124.72	$420.46

Technology adoption can be FAST



Source: Mai, Trieu, Paige Jadun, Jeffrey Logan, Colin McMillan, Matteo Muratori, Daniel Steinberg, Laura Vimmerstedt, Ryan Jones, Benjamin Haley, and Brent Nelson. 2018.Electrification Futures Study: Scenarios of Electric Technology Adoption and Power Consumption for the United States. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-71500.

Be in touch!

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