scout

U.S. DEPARTMENT OF ENERGY

Lawrence Berkeley National Laboratory | National Renewable Energy Laboratory
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WBS 3.5.5.20 (LBNL) | WBS 3.5.5.55 (NREL)

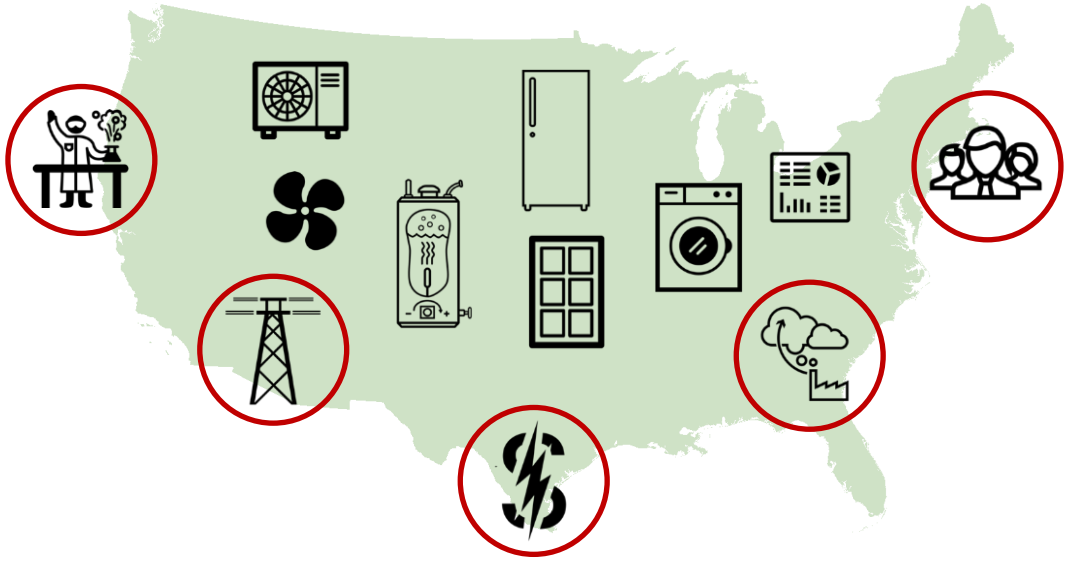
BERKELEY LAB NREL NATIONAL RENEWABLE ENERGY LABORATORY

Project Summary

Objective and outcome

Scout is building stock modeling software used to estimate near- and long-term impacts of energy efficiency, flexibility, and electrification technology deployment on U.S. national and regional building energy use, CO_2 emissions, and operating costs.

Scout helps EERE and BTO set program-wide goals and explore key deployment levers at a granular level and supports internal and external stakeholder engagement.



Team and Partners

LBNL	NREL
Aven Satre-Meloy, Co-PI	Chioke Harris, Co-PI
Jared Langevin, Co-PI	Andrew Speake
Handi Chandra Putra	Peter DeWitt

Stats

Performance Period: FY22–FY24

DOE budget: $750,000 (FY23 enacted) | Cost Share: $0

Milestone 1

- New minor Scout version released on GitHub

Milestone 2

- Updated Scout core Energy Conservation Measure (ECM) set and analysis results

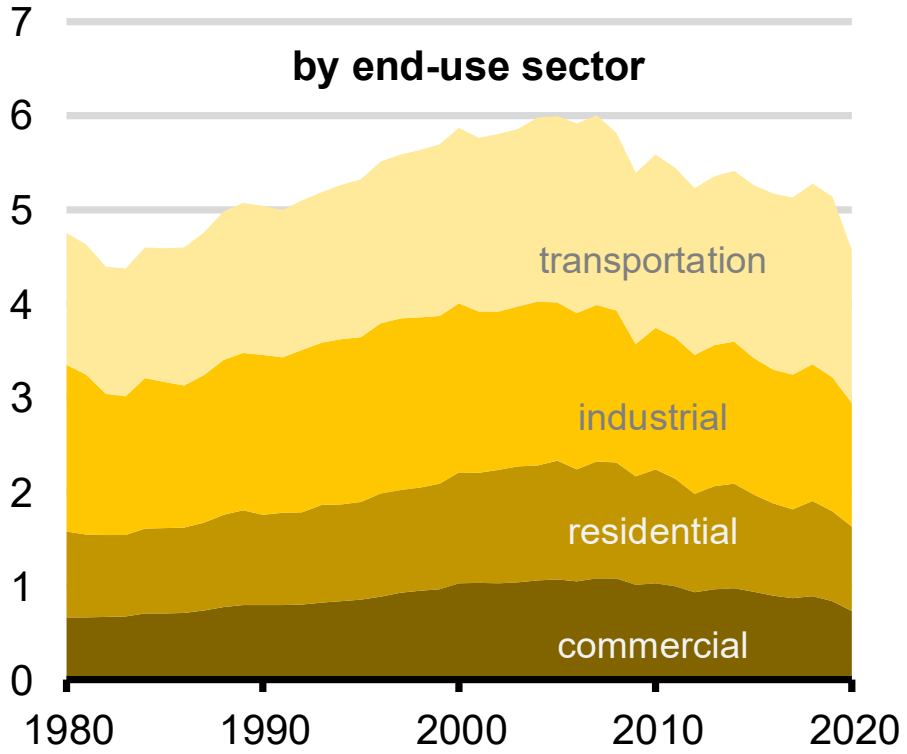
Milestone 3

- New major Scout version released on GitHub

Problem Statement

Buildings are a top source of electricity and energy use as well as energy-related CO_2 emissions in the U.S.

U.S. energy-related carbon dioxide emissions (1980–2020)
billion metric tons



Source: U.S. Energy Information Administration (EIA)

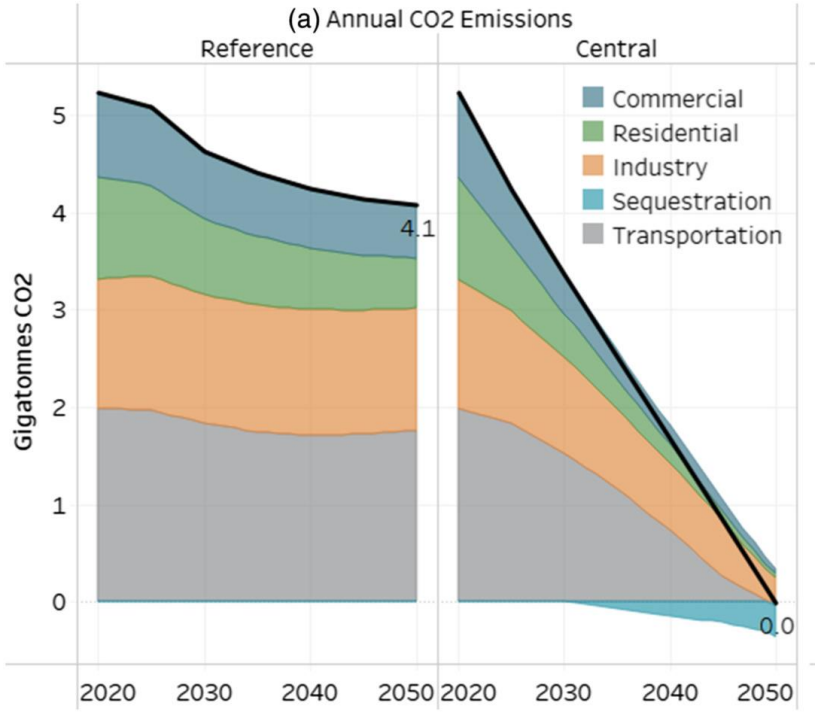
Scout supports BTO and its analysis stakeholders in conducting rapid assessments of potential building sector energy and emissions impacts through 2050. Scout's ability to represent a wide variety of existing and emerging building technologies provides useful quantitative evidence to highlight the role of building technologies in achieving economy-wide decarbonization.

Approach

Existing modeling and scenario tools tend to represent building technologies and adoption drivers with a coarse degree of detail

Economy-wide decarbonization

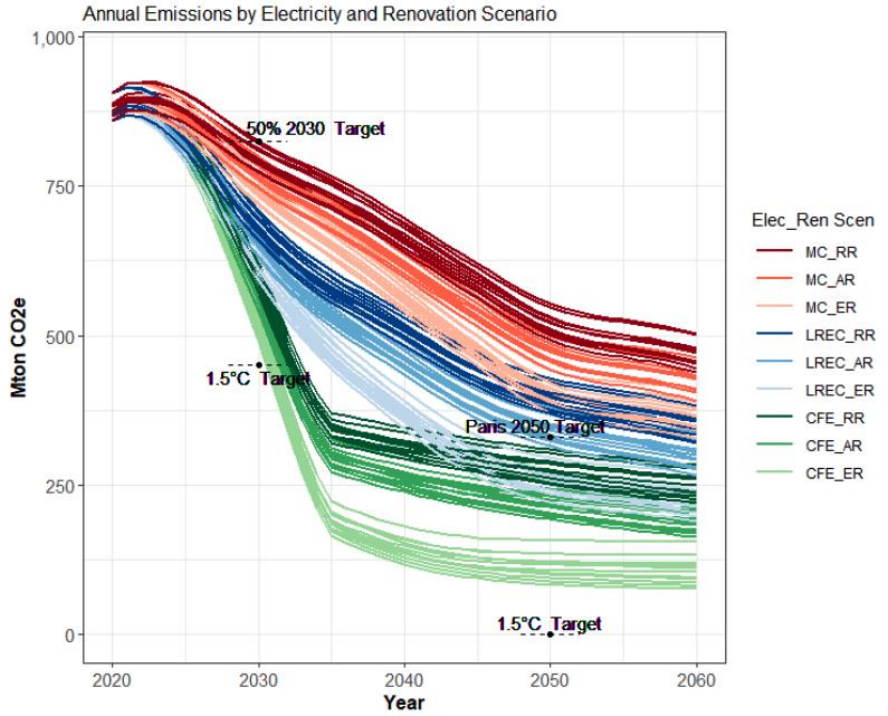
Limited representation of building end uses and technologies



Williams, J. H., et al. "Carbon-neutral pathways for the United States." *AGU Advances*, 2 (2021). https://doi.org/10.1029/2020AV000284

Buildings sector-specific decarbonization

Limited sectoral representation and coarse adoption assumptions



Berrill, P., et al. "Decarbonization pathways for the residential sector in the United States." *Nature Climate Change* 12, 712–718 (2022). https://doi.org/10.1038/s41558-022-01429-y

Approach

Scout can represent detailed portfolios of building technologies combined with sophisticated technology adoption dynamics

Baseline inputs

- Building Stock (# buildings, floor area)
- Technology Stock (# units, energy performance/cost, lifetime, adoption parameters)

Primary data sources:

Approach

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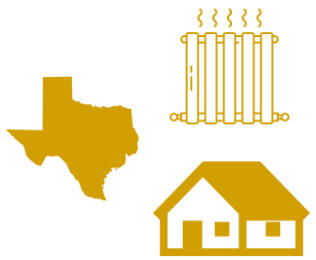
Baseline "micro-segment"

- Region/climate zone
- Building sector & type
- New vs. existing construction
- Fuel type
- End use
- Technology



e.g., space heating served by electric technologies in existing single-family homes in Texas

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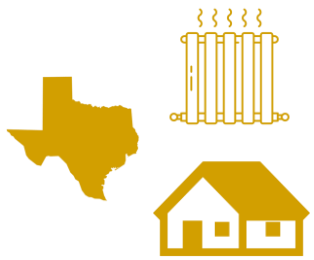

e.g., space heating served by electric technologies in existing single-family homes in Texas

Stock and flow dynamics

Existing stock **not up** for replacement

Existing stock **up** for replacement

New additions to stock

Other baseline micro-segments

Primary data sources:

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Scout Energy Conservation Measure (ECM)

- Applicable baseline micro-segment
- Cost, performance, lifetime
- Market entry year

e.g., ESTAR v6.1 Res. Air-source Heat Pump

Typical Capacity (kBtu/h)	36
SEER (Cooling)	16
HSPF (Heating)	9.2
Average Life (y)	15.3
Total Installed Cost (2022$)	6,940

Primary data sources:

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Measure Adoption (no competition)

Existing/new stock captured by measure

Primary data sources:

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Existing/new stock captured by measure

Measure Adoption (with competition)

Existing/new stock captured by measure A

Existing/new stock captured by measure B

Primary data sources:

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Existing/new stock captured by measure A

Existing/new stock captured by measure B

Simulation Output Metrics

Energy savings (source/site)
Electricity demand reduction (hourly load impacts)

Energy-related CO_2 emissions
Fugitive CO_2e emissions

Technology/consumer energy costs & cost effectiveness (IRR, simple payback, cost of conserved energy)

Primary data sources:

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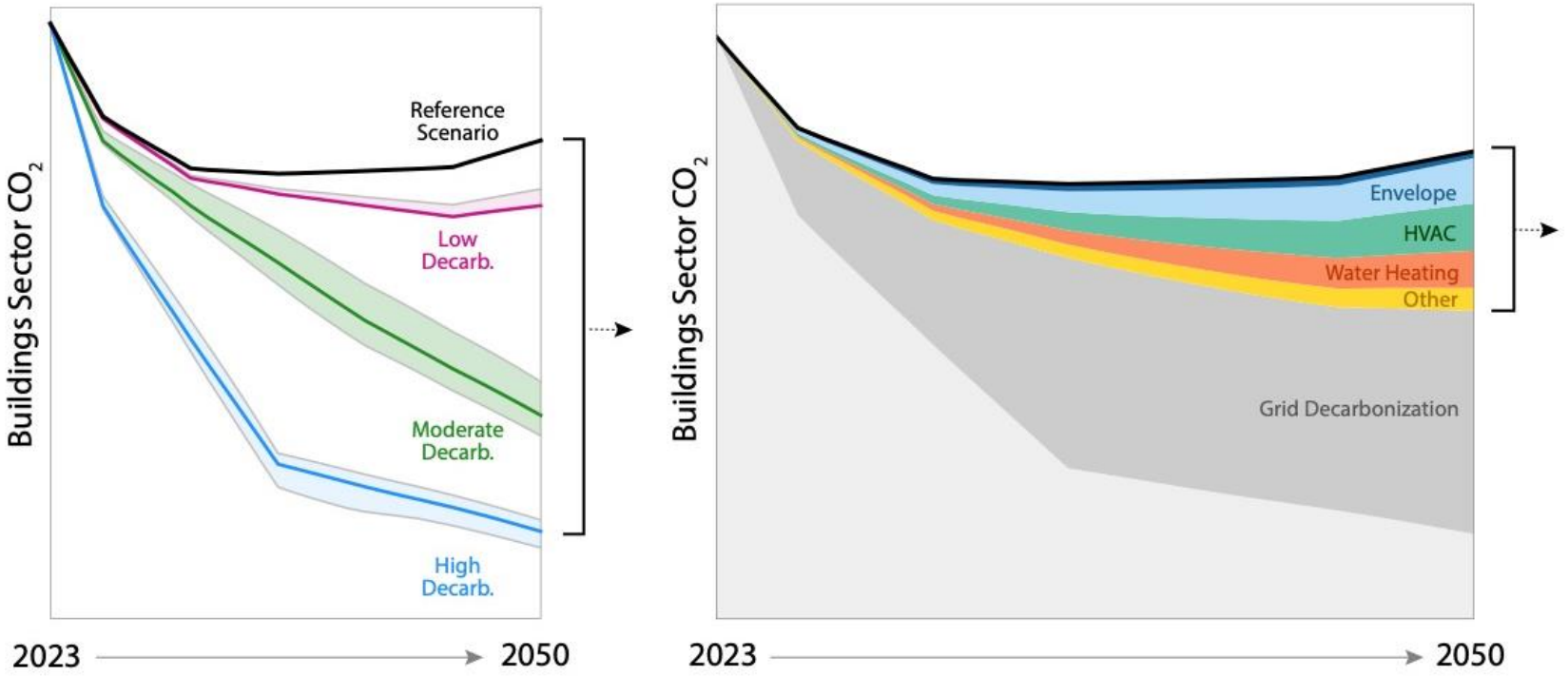
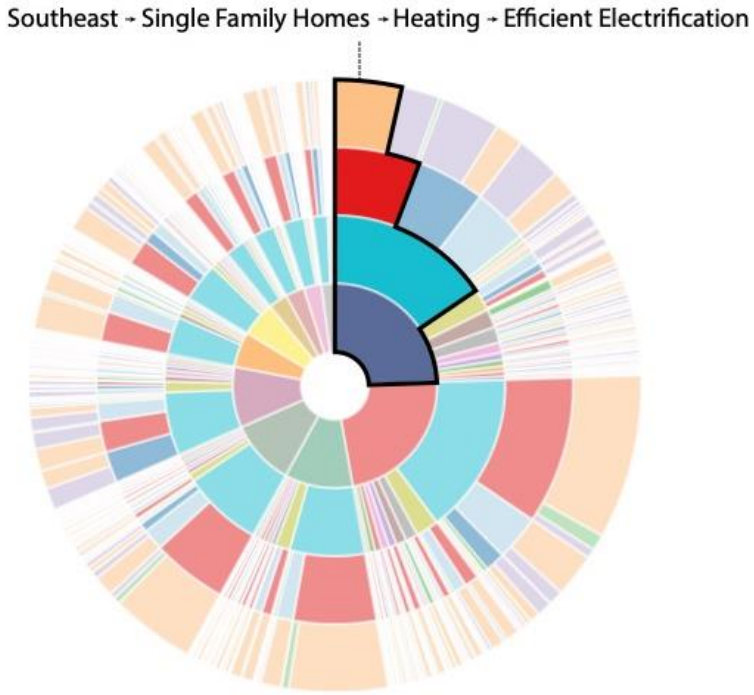
Building Measure* Features	Building and Equipment Stock Dynamics
Efficient electrification for heating/WH/cooking	Elevate minimum performance
Energy efficiency for electric and non-electric end uses	Introduce breakthrough technologies
Demand flexibility measures with shed/shift capabilities	Accelerate electrification
	Accelerate retrofit decisions

*We currently assess 170 building measures and 37 measure packages, available here.
Our measure set is regularly updated.

Alignment and Impact

Scout's analysis capabilities help EERE and BTO set program-wide goals and explore key deployment levers at a granular level





Preprint available: Langevin et al, "The Role of Buildings in U.S. Energy System Decarbonization by Mid-Century," https://dx.doi.org/10.2139/ssrn.4253001

Alignment and Impact

Scout is open-source software with supporting user guides and documentation that enables stakeholders to conduct their own analyses

We define success as the wide use of Scout capabilities and datasets across policy and research domains to improve the understanding of building decarbonization pathways as well as key technology impacts and deployment levers.

Scout software available at:
https://github.com/trynthink/scout
Quick start guides available at:
https://scout-bto.readthedocs.io/en/latest/

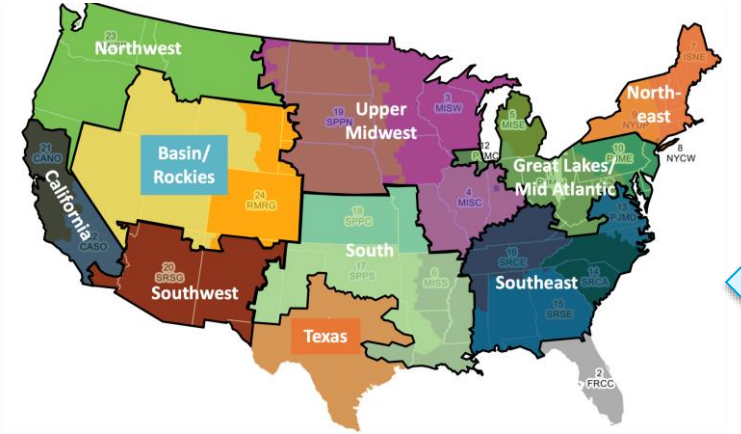
Scout web application available at:
https://scout.energy.gov/

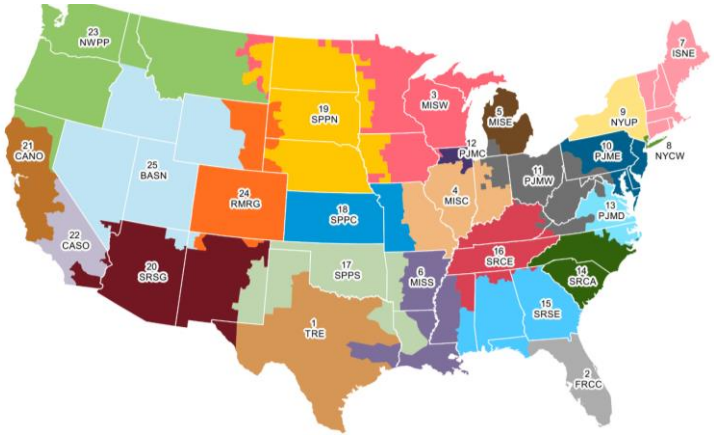
Scout benchmark scenarios for U.S. building energy use and CO_2 emissions to 2050 available at:
https://zenodo.org/record/6577017

Approach

Technical challenges and barriers to Scout development relate primarily to data and modeling gaps that we aim to address over time

Key modeling gaps
Technology adoption scenarios
Geographic resolution
Demand flexibility modeling
Technology costs
Endogenous electrification modeling





Approach

Scout's AOP specifies key areas of approach refinement and development to address key gaps and analysis barriers

1. **Analysis capabilities and workflow**

2. **Energy Conservation Measure (ECM) updating and maintenance**

3. **Baseline data updating and maintenance**

4. **Web application capabilities and maintenance**

5. **Documentation, support, and communication**

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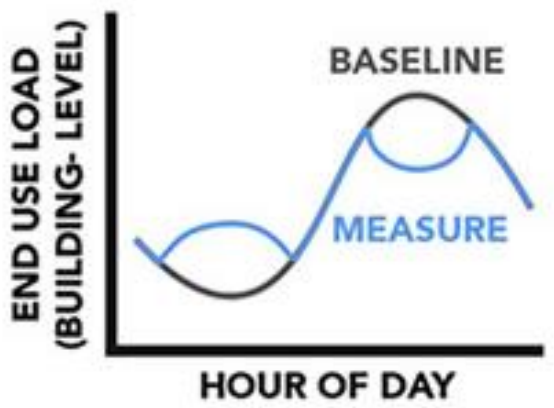
Approach

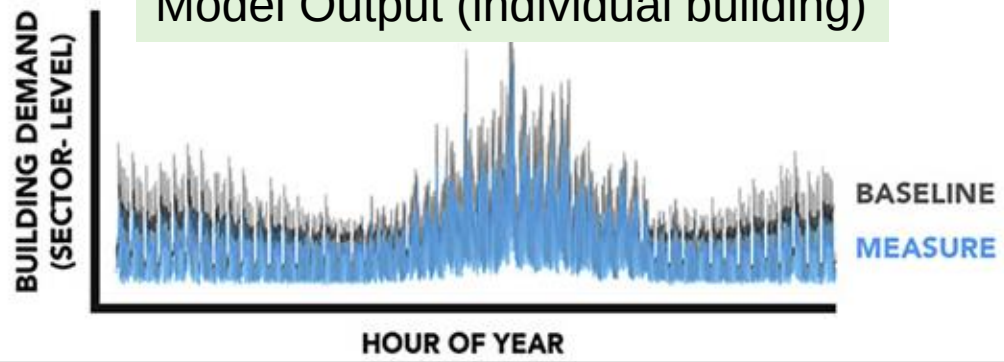
Key technical capability advancement: detailed representation of demand flexibility measures to assess electricity load impacts

Model Inputs:

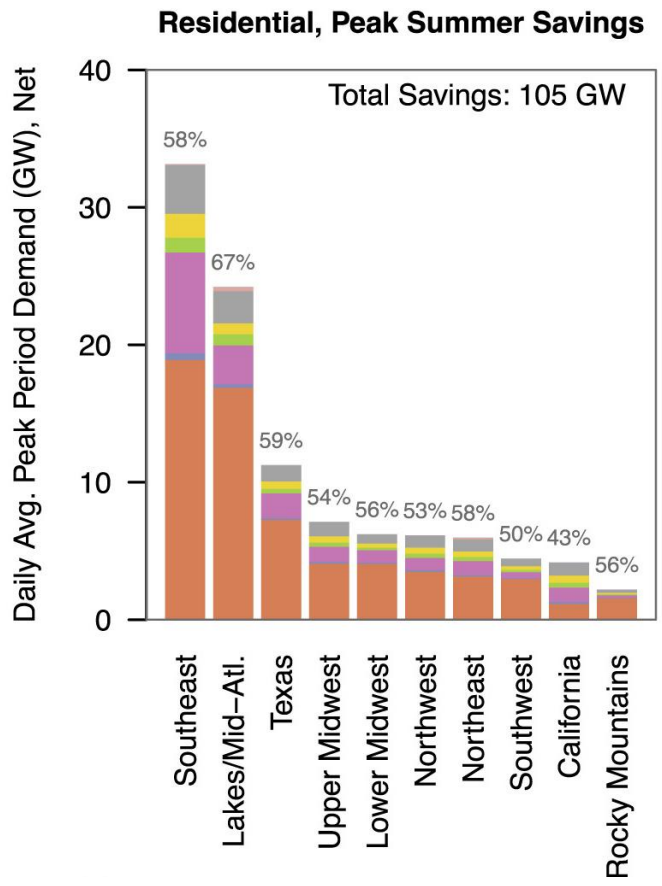


U.S. power system loads by region, annual (2020–2050) and hourly

Model Output (individual building)



Model Output (regional stock)



Langevin et al. (2021), “US building energy efficiency and flexibility as a grid resource,” https://doi.org/10.1016/j.joule.2021.06.002

Progress and Future Work

Scout's accomplishments include high-impact publications, support for EERE goals development, and stakeholder engagement

Publication Title	Citation and Link	Journal
Assessing the Potential to Reduce U.S. Building CO2 Emissions 80% by 2050	Langevin et al. (2019): 10.1016/j.joule.2019.07.013	Joule
Assessing the time-sensitive impacts of energy efficiency and flexibility in the US building sector	Satre-Meloy and Langevin (2019): 10.1088/1748-9326/ab512e	ERL Environmental Research Letters
US building energy efficiency and flexibility as a grid resource	Langevin et al. (2021): 10.1016/j.joule.2021.06.002	Joule
A global comparison of building decarbonization scenarios by 2050 towards 1.5–2 °C targets	Camarasa et al. (2022): https://doi.org/10.1038/s41467-022-29890-5	nature COMMUNICATIONS
The Role of Buildings in U.S. Energy System Decarbonization by Mid-Century	Langevin et al. (Under Review): 10.2139/ssrn.4253001	One Earth

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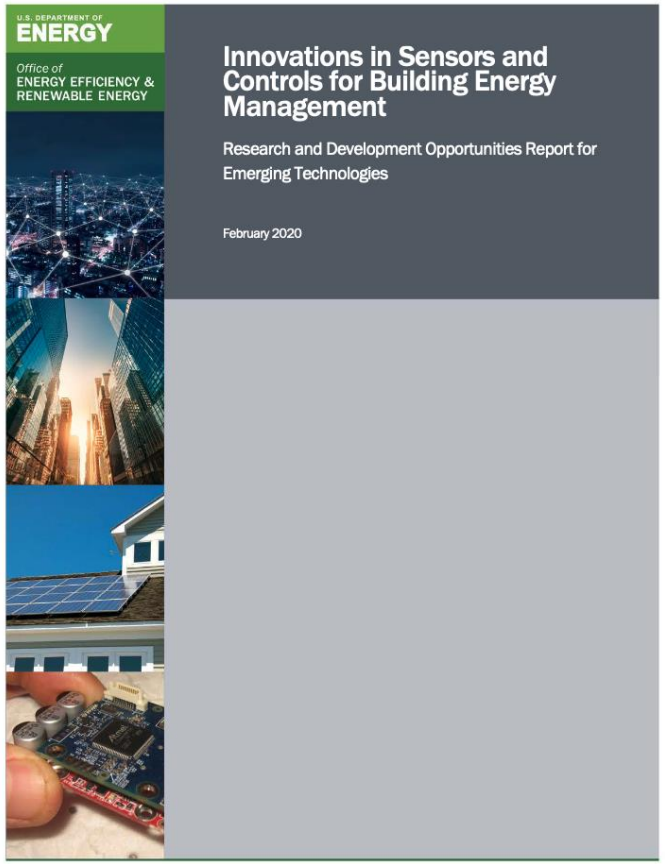
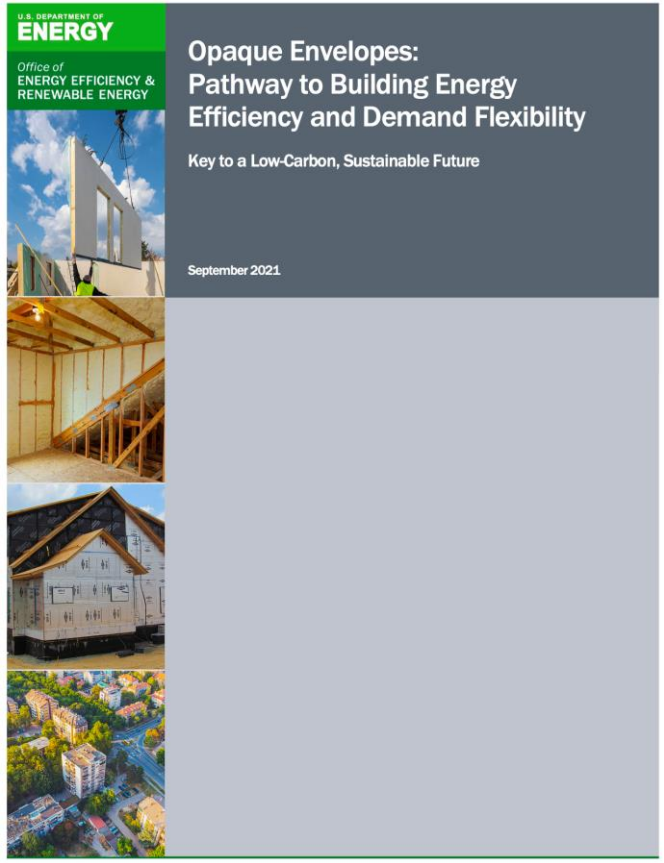




Scout is currently used to estimate technology installed cost and performance targets, as well as potential energy, CO_2 emissions, and operational cost savings, for emerging technologies covered in BTO's Research and Development Opportunities (RDO) Reports

Progress and Future Work

Scout's accomplishments include high-impact publications, support for EERE goals development, and stakeholder engagement

A vision for a net-zero U.S. building sector by 2050

Support rapid decarbonization of the U.S. building stock in line with economy-wide net-zero emissions by 2050 while centering equity and benefits to communities

Prioritize equity, affordability, and resilience

Ensure that 40% of the benefits of federal building decarbonization investments flow to disadvantaged communities

Reduce the cost of decarbonizing key building segments 50% by 2035 while also reducing consumer energy burdens

Increase the ability of communities to withstand stress from climate change, extreme weather, and grid disruptions

Increase building energy efficiency

Reduce onsite energy use intensity in buildings 30% by 2035 and 45% by 2050, compared to 2005

Accelerate onsite emissions reductions

Reduce onsite fossil-based CO_2 emissions in buildings 25% by 2035 and 75% by 2050, compared to 2005

Transform the grid edge at buildings

Increase building demand flexibility potential 3X by 2050, compared to 2020, to enable a net-zero grid, reduce grid edge infrastructure costs, and improve resilience.

These <u>draft</u> goals were presented and discussed during the "BTO Strategy and Roadmap" session at BTO Peer Review

Stanford ENGINEERING | Energy Modeling Forum

U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY — Decarbonizing Energy through Collaborative Routes and Benefits (DECARB)

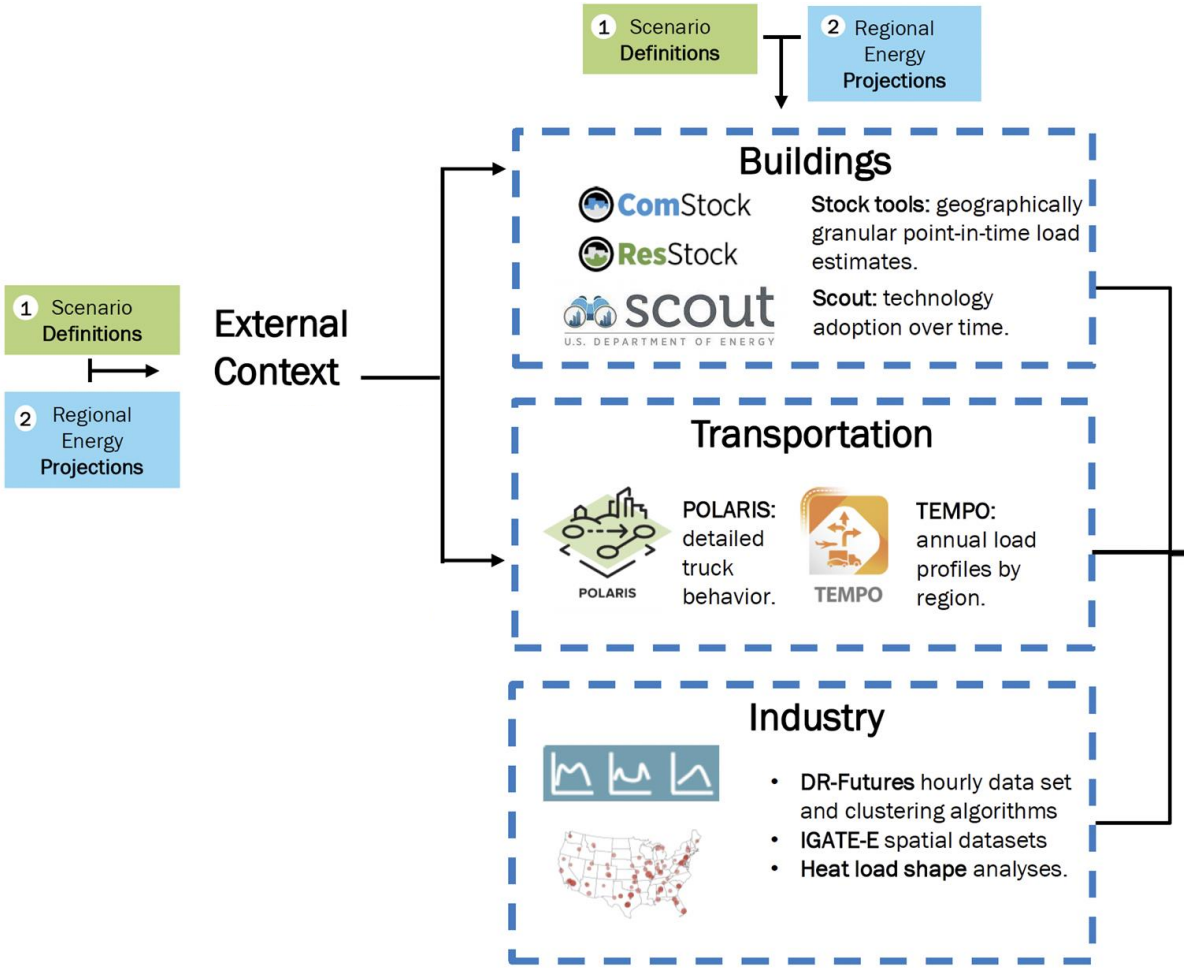
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY — Low Emissions Electricity Program & GHG Corporate Reporting

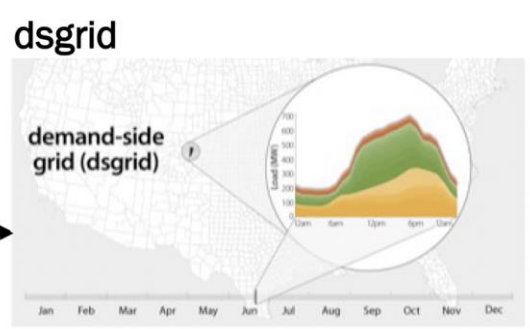
Global Change Analysis Model (GCAM)

ipcc INTERGOVERNMENTAL PANEL ON climate change — IPCC 6th Assessment Report (AR6)

Progress and Future Work

Primary obstacles are related to data limitations and modeling complexity inherent to more spatially- and temporally-resolved analyses





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

Decarbonizing Energy through Collaborative Routes and Benefits (DECARB)

Task 6: Project Electricity Load at High Spatiotemporal Resolution

Progress and Future Work

Future work on Scout will focus on developing capabilities that address existing gaps and meet the needs of a growing set of stakeholders

EERE/BTO:
Track and update building and economy-wide decarbonization scenarios as needed to inform strategic priorities.

Researchers:
Rapidly assess impacts of existing and emerging technologies and operational approaches.

State/regional policy officials:
Represent state-specific policy and technology drivers for building decarbonization and conduct analyses at the state and national levels.

Utilities and grid planners:
Represent demand-side resource impacts on grid futures with varying levels of low-carbon electricity deployment.

Thank You

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REFERENCE SLIDES

Project Execution

	FY2022				FY2023				FY2024			
Planned budget												
Spent budget												
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Past Work												
Q2 Milestone: New minor Scout version released on GitHub												
Q3 Milestone: Updated Scout core ECM set and analysis results												
Q4 Milestone: New major Scout version released on GitHub												
Current/Future Work												
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Q4 Milestone: New major Scout version released on GitHub												

Go/No-Go Decision	Go/No-Go Description	Go/No-Go Criteria	Go/No-Go Due Date
New Scout version	Fully documented Scout engine available for public release along with stock and measure datasets.	Public GitHub repository contents available to TMs.	8/31 (in each of 2022, 2023, and 2024)

- FY23 ”New minor Scout version” milestone delayed ~1 month due to unanticipated data updating issue

Team

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BERKELEY LAB

Stakeholders/Partners

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

ACEEE
American Council for an Energy-Efficient Economy

Brattle

IMPEL