

Performing Organization(s): NREL PI Name and Title: Andrew Parker, Engineer IV, Commercial Buildings Controls and Analytics Group PI Tel and/or Email: 303-274-4568, <u>andrew.parker@nrel.gov</u> WBS #2.5.2.06

Project Summary

Objective and outcome

When a city, state, utility, or national policymaker, company, or researcher wants to know: "How much energy are the buildings using, for what, and when for XYZ location?" or "What's the (energy, carbon, etc.) impact of changing XYZ in my building stock?" They can get a credible, defensible answer from ComStock datasets



Team and Partners

FY23: NREL, roughly 3 FTE

Past: major collaboration with LBNL and ANL, and support from our 90+ member Technical Advisory Group through fall 2021

<u>Stats</u>

Performance Period: 10/1/2022-12/31/2023 DOE budget: \$1,100k, Cost Share: \$0k Milestone 1: ComStock Progress Report Milestone 2: Draft Technical Assistance Publication Milestone 3: AWS Workflow Demonstration and User Feedback Report Milestone 4: Novel Sampling Approach Demonstration

BTO Has Ambitious Goals for Buildings!



- Less efficient
- Fossil-fuel-reliant
- Inflexible

• Flexible

BTO Must Influence Others to Accomplish its Goals



A lack of credible and relevant information about current building stock and impact of tech at scale contributes to inaction by

cities, states, utilities, and other major stakeholders



For example, will electrification of buildings...

- Reduce carbon emissions in my city?
- Overload the grid?
- Be feasible in my building stock?



Input to Output to Impact – Achieving BTO Goals

Put actionable information in the hands of decision-makers

City/State/Federal Policymakers

Reduce staff time and effort to inform decisions by providing clear and relevant data

Identify the key levers for change in underserved segments

Provide customers with comprehensive energy efficiency and beneficial electrification programs

Utilities

Portfolio Owners

Quantify impacts and benefits across many buildings

Incorporate energy efficiency, electrification, and demand flex as part of integrated resource planning Identify the types of buildings where benefits are largest

Input to Output to Impact – Logic Model

Inputs	Activities	Outputs	Initial Outcomes	Ultimate Outcomes
Existing building stock characteristics Historical energy consumption data Building domain expertise	Analyze existing building stock Analyze impact of existing and new technologies on existing building stock	Spatially and temporally detailed datasets of: Current energy consumption and emissions Potential impact of: — energy efficiency	Federal, city, and state policymakers and regulators (PUCs) can review the magnitude and equity distribution of deploying EE, electrification, and DF in their geography of interest.	Federal, city, and state policymakers and regulators choose to implement programs and policies that increase equitable deployment of, EE, electrification and DF.
		electrificationdemand flexibility		

Output – Credible Data for Baseline and Technology Impacts

Credible Baseline Data

Describes how, when, and where energy is used in buildings **today**

Public database of 350,000 individual building models and their energy end-use load profiles

Credible Technology Impacts

Describes how, when, and where energy is used in **"what if" scenarios**

Adds measure impact profiles for energy efficiency and electrification packages

"We want to assess potential energy and cost savings for municipal buildings after electrification and energy conservation measure implementations."

Zahra Seblini, City of Detroit's Office of Sustainability

Technical Approach – Modeling Workflow



- 1. Describe the U.S. building stock quantitatively
- 2. Sample the description
- 3. Model the samples (350,000 models)
- 4. Model changes to the samples energy efficiency, electrification, etc.
- 5. Publish description, samples, models, results, aggregations, visualizations, and documentation

Simple, fast

Simple & fast enough

Complex, slow

Building Characteristics



Create distributions of building characteristics from available data sources \rightarrow



- CoStar
- EIA CBECS
- ASHRAE
- HIFLD
- NFRC

26.4%

- Analysis of AMI
- LightBox
- **CPUC DEER**
- Code Adoption
 - (see documentation for full list & acronyms)

Physics-Based Modeling

High granularity: 350,000 models



Foundational DOE energy models



Detailed sub-hourly energy simulations



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NRE

High Performance Computing

350,000s simulations per upgrade x 10 upgrades (EUSS 2023 rel. 1) = 3,500,000 simulations today!

NREL's supercomputer

Cloud computing



Big data technology stack



Technical Approach – Calibration



Source: NREL / EULP Dataset Release Webinar

Deployment Approach – Impact Scaling



Deployment Approach



U.S. DEPARTMENT OF ENERGY

Outreach and User Engagement

Reports for key use cases

3 Stock Segmentation by Size

Figure 2 shows building stock characteristics by building size. Table 2 in Appendix B provides these data in a tabular format. Emissions include both direct and indirect greenhouse gas emissions. Direct emissions are from on-site fossil fuel combustion, and indirect emissions are from regional electricity generation. Direct emissions include both combustion and pre-combustion emissions (e.g., methane leakage for natural gas) and are based on RESNET/ANSI/ICC Standard 301 2018. Indirect emissions are calculated using state level data from the EPA for 2019 (cGRID, n.d.).

Building energy use and emissions depend on the total floor area, not the number of buildings. This is because lighting, heating, cooling, and ventilation scale with floor area.





ComStock Reference Documentation: Version 1

Andrew Parker, Henry Horsey, Matthew Dahlhausen, Marlena Praprost, Christopher CaraDonna, Amy LeBar, and Lauren Klun

National Renewable Energy Laboratory

Online documentation & tutorials



Stakeholder feedback

- City & state policymakers
- Utilities
- Large portfolio owners
- Consulting firms & nonprofits
- Academic researchers



Data Access – Pathways for All Types







Aggregate files



Full database access



Building models



ComStock Baseline + 10 Measures Available Now! Access at: <u>https://comstock.nrel.gov/</u>

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4	5161.02	64372.5	53924.5	279022	4016.71	4639.47	30782.4	3537.78	1073.37	12868.5	749.638	92419.7	0	1116.95	0	13100.5	19440.2	1005.09	0	251.63	222.748	1445.63	1149.44	310.315	0	2224442	565,564	124086	114.39	1046.68
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4 4 6	5161.02 5161.02 5161.02 5161.02	54977.5 52339.5 52465.7 50715.3 49445.8	33050.6 27671.9 26781.6 24345.1 22207.5	221720 222831 215085 211398	1144.31 1144.31 899.759 899.759 899.759	1324.21 1324.21 1035.59 1035.59 1035.59	54548.2 52233.7 53175.4 56724.3 58966.9	2479.91 2479.91 2479.91 2479.91 2479.91	354.964 354.964 603.148 603.148 603.148	45110.2 44606.6 43912.9 43612.4	780.63 780.63 630.025 630.025 630.025	115337 114659 115124 114712 114349	0 0 0 0 0 0	9053.52 9495.65 9495.65 9495.65	-13703 -15759 -17846 -19225	11339 11802.2 11769.5 11936.6	21775.8 21601 21601 21601	1767.07 1819.13 1819.13 1819.13	0 0 0	474.449 458.199 437.265 418.106	625.314 0 65.4976 441.168	5370.3 5702.97 5993.06 8064.36	2045.18 2105.64 2105.64 2105.64	1061.3 1138.01 1138.01 1138.01	0 0 0 0	1803894 1805154 1745159 1702787	160.089 126.383 126.383 126.383	215430 223602 231113 215378	203.589 210.188 210.188 210.188	8474.23 8895.25 8895.25 8895.25
4 4 6	5161.02 5161.02 5161.02 5161.02 5161.02	54977.5 52339.5 52465.7 50715.3 49445.8 47911.4	33050.6 27671.9 26781.6 24345.1 22207.5 19853.8	221720 222831 215085 211398 205557	1144.31 1144.31 899.759 899.759 899.759 899.759	1324.21 1324.21 1035.59 1035.59 1035.59 1035.59	54548.2 52233.7 53175.4 56724.3 58966.9 53367.9	2479.91 2479.91 2479.91 2479.91 2479.91 2479.91	354.964 354.964 603.148 603.148 603.148 603.148	46211.4 45110.2 44606.6 43912.9 43612.4 43239.5	780.63 780.63 630.025 630.025 630.025 630.025	115337 114659 115124 114712 114349 114070	0 0 0 0 0 0 0 0	9053.52 9495.65 9495.65 9495.65 9495.65	-13703 -15759 -17846 -19225 -20549	11339 11802.2 11769.5 11936.6 10869.7	21775.8 21601 21601 21601 21601	1767.07 1819.13 1819.13 1819.13 1819.13 1819.13	0 0 0 0	474.449 458.199 437.265 418.106 397.669	625.314 0 65.4976 441.168 310.67	5370.3 5702.97 5993.06 8064.36 10115.3	2045.18 2105.64 2105.64 2105.64 2105.64	1061.3 1138.01 1138.01 1138.01 1138.01	0 0 0 0 0	1803894 1805154 1745159 1702787 1651577	160.089 126.383 126.383 126.383 126.383	215430 223602 231113 215378 214043	203.589 210.188 210.188 210.188 210.188 210.188	8474.23 8895.25 8895.25 8895.25 8895.25
4 6 6 7	5161.02 5161.02 5161.02 5161.02 5161.02 5161.02	54977.5 52339.5 52465.7 50715.3 49445.8 47911.4 48126	33050.6 27671.9 26781.6 24345.1 22207.5 19853.8 19552.8	221720 222831 215085 211398 205557 207562	1144.31 1144.31 899.759 899.759 899.759 899.759 899.759 845.037	1324.21 1324.21 1035.59 1035.59 1035.59 1035.59 971.187	54548.2 52233.7 53175.4 56724.3 58966.9 53367.9 57299.1	2479.91 2479.91 2479.91 2479.91 2479.91 2479.91 2479.91 2561.02	354.964 354.964 603.148 603.148 603.148 603.148 603.148	46211.4 45110.2 44606.6 43912.9 43612.4 43239.5 42236.4	780.63 780.63 630.025 630.025 630.025 630.025 748.669	115337 114659 115124 114712 114349 114070 115699	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	9053.52 9495.65 9495.65 9495.65 9495.65 9053.52	-13703 -15759 -17846 -19225 -20549 -21846	11339 11802.2 11769.5 11936.6 10869.7 12325.9	21775.8 21601 21601 21601 21601 21601 21601	1767.07 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13	0 0 0 0 0 0 0 0 0 0 0	474.449 458.199 437.265 418.106 397.669 392.347	625.314 0 65.4976 441.168 310.67 233.677	5370.3 5702.97 5993.06 8064.36 10115.3 10045	2045.18 2105.64 2105.64 2105.64 2105.64 2105.64	1061.3 1138.01 1138.01 1138.01 1138.01 1138.01 1192.51	0 0 0 0 0	1803894 1805154 1745159 1702787 1651577 1653008	160.089 126.383 126.383 126.383 126.383 126.383 118.435	215430 223602 231113 215378 214043 210594	203.589 210.188 210.188 210.188 210.188 210.188 210.188	8474.23 8895.25 8895.25 8895.25 8895.25 8895.25 8474.23
4 6 7	5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02	54977.5 52339.5 52465.7 50715.3 49445.8 47911.4 48126 46419.9	33050.6 27671.9 26781.6 24345.1 22207.5 19853.8 19552.8 16796.9	221720 222831 215085 211398 205557 207562 198396	1144.31 1144.31 899.759 899.759 899.759 899.759 899.759 845.037 845.037	1324.21 1324.21 1035.59 1035.59 1035.59 1035.59 971.187 971.187	54548.2 52233.7 53175.4 56724.3 58966.9 53367.9 57299.1 56103.7	2479.91 2479.91 2479.91 2479.91 2479.91 2479.91 2479.91 2561.02 2561.02	354.964 354.964 603.148 603.148 603.148 603.148 603.148 603.148 603.148	46211.4 45110.2 44606.6 43912.9 43612.4 43239.5 42236.4 41922.3	780.63 780.63 630.025 630.025 630.025 630.025 748.669 748.669	115337 114659 115124 114712 114349 114070 115699 115454	000000000000000000000000000000000000000	9053.52 9495.65 9495.65 9495.65 9495.65 9053.52 9053.52	-13703 -15759 -17846 -19225 -20549 -21846 -22957	11339 11802.2 11769.5 11936.6 10869.7 12325.9 14555.5	21775.8 21601 21601 21601 21601 21601 21601	1767.07 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	474.449 458.199 437.265 418.106 397.669 392.347 422.789	625.314 0 65.4976 441.168 310.67 233.677 560.526	5370.3 5702.97 5993.06 8064.36 10115.3 10045 10782.1	2045.18 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64	1061.3 1138.01 1138.01 1138.01 1138.01 1138.01 1192.51	0 0 0 0 0 0	1803894 1805154 1745159 1702787 1651577 1653008	160.089 126.383 126.383 126.383 126.383 126.383 118.435	215430 223602 231113 215378 214043 210594 208903	203.589 210.188 210.188 210.188 210.188 210.188 210.188	8474.23 8895.25 8895.25 8895.25 8895.25 8895.25 8474.23 8474.23
4 6 7 5	5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02	54977.5 52339.5 52465.7 50715.3 49445.8 47911.4 48126 46419.9	33050.6 27671.9 26781.6 24345.1 22207.5 19853.8 19552.8 16796.9	231322 221720 222831 215085 211398 205557 207562 198396	1144.31 1144.31 899.759 899.759 899.759 899.759 899.759 845.037 845.037	1324.21 1324.21 1035.59 1035.59 1035.59 1035.59 1035.59 971.187 971.187	54548.2 52233.7 53175.4 56724.3 58966.9 53367.9 57299.1 56103.7	2479.91 2479.91 2479.91 2479.91 2479.91 2479.91 2479.91 2561.02 2561.02	354.964 354.964 603.148 603.148 603.148 603.148 603.148 603.148 603.148	46211.4 45110.2 44606.6 43912.9 43612.4 43239.5 42236.4 41922.3 41922.3	780.63 780.63 630.025 630.025 630.025 630.025 748.669 748.669	115337 114659 115124 114712 114349 114070 115699 115454	000000000000000000000000000000000000000	9053.52 9495.65 9495.65 9495.65 9495.65 9053.52 9053.52	-13703 -15759 -17846 -19225 -20549 -21846 -22957	11339 11802.2 11769.5 11936.6 10869.7 12325.9 14555.5	21775.8 21601 21601 21601 21601 21601 21601 21601	1767.07 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13	0 0 0 0 0 0	474.449 458.199 437.265 418.106 397.669 392.347 422.789	625.314 0 65.4976 441.168 310.67 233.677 560.526	5370.3 5702.97 5993.06 8064.36 10115.3 10045 10782.1	2045.18 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64	1061.3 1138.01 1138.01 1138.01 1138.01 1138.01 1192.51 1192.51	0 0 0 0 0 0 0 0	1803894 1805154 1745159 1702787 1651577 1653008 1593364	160.089 126.383 126.383 126.383 126.383 126.383 118.435 118.435	215430 223602 231113 215378 214043 210594 208903 207374	203.589 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188	8474.23 8895.25 8895.25 8895.25 8895.25 8895.25 8474.23 8474.23
4 6 7 5	5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02	54977.5 52339.5 52465.7 50715.3 49445.8 47911.4 48126 46419.9 45063	33050.6 27671.9 26781.6 24345.1 22207.5 19853.8 19552.8 16796.9 14734.6	231322 221720 222831 215085 211398 205557 207562 198396 194219	1144.31 1144.31 899.759 899.759 899.759 899.759 845.037 845.037 845.037	1324.21 1324.21 1035.59 1035.59 1035.59 1035.59 971.187 971.187 971.187	54548.2 52233.7 53175.4 56724.3 58966.9 53367.9 57299.1 56103.7 50501.3	2473.31 2479.91 2479.91 2479.91 2479.91 2479.91 2479.91 2561.02 2561.02 2561.02	354,964 354,964 603,148 603,148 603,148 603,148 603,148 603,148 603,148	46211.4 45110.2 44606.6 43912.9 43612.4 43239.5 42236.4 41922.3 41185.3	780.63 780.63 630.025 630.025 630.025 630.025 748.669 748.669 748.669	115337 114659 115124 114712 114349 114070 115699 115699 115454 115044	000000000000000000000000000000000000000	9053.52 9495.65 9495.65 9495.65 9495.65 9053.52 9053.52 9053.52	-13703 -13703 -15759 -17846 -19225 -20549 -21846 -22957 -21846	11339 11802.2 11769.5 11936.6 10869.7 12325.9 14555.5 14740.9	21775.8 21601 21601 21601 21601 21601 21601 21601	1767.07 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13	0 0 0 0 0 0 0	474.449 458.199 437.265 418.106 397.669 392.347 422.789 364.388	625.314 0 65.4976 441.168 310.67 233.677 560.526 374.464	5370.3 5702.97 5993.06 8064.36 10115.3 10045 10782.1 10706.5	2045.18 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64	1061.3 1138.01 1138.01 1138.01 1138.01 1138.01 1138.01 1192.51 1192.51		1803834 1805154 1745159 1702787 1651577 1653008 1593364 1593364	160.089 126.383 126.383 126.383 126.383 126.383 118.435 118.435 118.435	215430 223602 231113 215378 214043 210594 208903 207374	203.589 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188	8474.23 8895.25 8895.25 8895.25 8895.25 8474.23 8474.23 8474.23
4 6 7 5 1	5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02	54977.5 52339.5 52465.7 50715.3 49445.8 47911.4 48126 46419.9 45063 43312.9	33050.6 27671.9 26781.6 24345.1 22207.5 19853.8 19552.8 16796.9 14734.6 12748.7	231322 221720 222831 215085 211398 205557 207562 198396 194219 187717	1144.31 1144.31 899.759 899.759 899.759 899.759 845.037 845.037 845.037 845.037	1324.21 1324.21 1035.59 1035.59 1035.59 1035.59 971.187 971.187 971.187	54548.2 52233.7 53175.4 56724.3 58966.9 53367.9 57299.1 56103.7 50501.3 51539.8	2473.31 2479.91 2479.91 2479.91 2479.91 2479.91 2561.02 2561.02 2561.02 2561.02	354,964 354,964 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148	46211.4 45110.2 44606.6 43912.9 43612.4 43239.5 42236.4 41922.3 41185.3 40721.6	780.63 780.63 630.025 630.025 630.025 630.025 748.669 748.669 748.669 748.669	115337 114659 115124 114712 114349 114070 115699 115454 115044 114811	0 0 0 0 0 0 0 0 0	9053.52 9495.65 9495.65 9495.65 9495.65 9053.52 9053.52 9053.52 9053.52	-1110 -13703 -15759 -17846 -19225 -20549 -21846 -22957 -24111 -25148	11339 11802.2 11769.5 11936.6 10869.7 12325.9 14555.5 14740.9 15594.4	21775.8 21601 21601 21601 21601 21601 21601 21601 21601 21601	1767.07 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13	0 0 0 0 0 0 0 0	474.449 458.199 437.265 418.106 397.669 392.347 422.789 364.388 343.17	625.314 0 65.4976 441.168 310.67 233.677 560.526 374.464 118.009	5370.3 5702.97 5993.06 8064.36 10115.3 10045 10782.1 10706.5 11496.1	2045.18 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64	1061.3 1138.01 1138.01 1138.01 1138.01 1138.01 1192.51 1192.51 1192.51	0 0 0 0 0 0 0 0 0 0 0	1803834 1803834 1805154 17451559 1702787 1651577 1651577 1653008 1593364 1546830 1487583	160.089 126.383 126.383 126.383 126.383 126.383 118.435 118.435 118.435 118.435	215430 223602 231113 215378 214043 210594 208903 207374 207074	203.589 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188	8474.23 8895.25 8895.25 8895.25 8895.25 8474.23 8474.23 8474.23 8474.23
4 6 7 5 1 6 7	5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02	54977.5 52339.5 52465.7 50715.3 49445.8 47911.4 48126 46419.9 45063 43312.9 44542.2	33050.6 27671.9 26781.6 24345.1 22207.5 19853.8 19552.8 16796.9 14734.6 12748.7 15374.4	231322 221720 222831 215085 211398 205557 207562 198396 194219 187717 191994	1144.31 1144.31 899.759 899.759 899.759 899.759 845.037 845.037 845.037 845.037 845.037	1324.21 1324.21 1035.59 1035.59 1035.59 1035.59 971.187 971.187 971.187 971.187	54548.2 52233.7 53175.4 56724.3 58966.9 53367.9 57299.1 56103.7 50501.3 51539.8 49331.8	2473.31 2479.91 2479.91 2479.91 2479.91 2479.91 2561.02 2561.02 2561.02 2561.02 2561.02 2561.02	354,964 354,964 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148	46211.4 45110.2 44606.6 43912.9 43612.4 43239.5 42236.4 41922.3 41185.3 40721.6 39750.9	780.63 780.63 630.025 630.025 630.025 630.025 748.669 748.669 748.669 748.669 905.812	115337 114659 115124 114712 114349 114070 115699 115454 115044 114811 116215	0 0 0 0 0 0 0 0 0 0	9053.52 9495.65 9495.65 9495.65 9495.65 9053.52 9053.52 9053.52 9053.52 9053.52 8976.77	-13703 -15759 -17846 -19225 -20549 -21846 -22957 -24111 -25148 -25999	11339 11802.2 11769.5 11936.6 10869.7 12325.9 14555.5 14740.9 15594.4 17243.1	21775.8 21601 21601 21601 21601 21601 21601 21601 21601 21601 21601 21601	1767.07 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13	0 0 0 0 0 0 0 0 0	474.449 458.199 437.265 418.106 397.669 392.347 422.789 364.388 343.17 328.481	625.314 0 65.4976 441.168 310.67 233.677 560.526 374.464 118.009 984.734	5370.3 5702.97 5993.06 8064.36 10115.3 10045 10782.1 10706.5 11496.1 11886.6	2045.18 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64	1061.3 1138.01 1138.01 1138.01 1138.01 1138.01 1192.51 1192.51 1192.51 1192.51 1088.55		1803824 1803894 1805154 1745159 1702787 1651577 1651577 1653008 1593364 1546830 1487583 1538376	160.089 126.383 128.383 128.435 128.435 128.435 128.435 128.435 128.435 128.435 128.435 128.435	215430 223602 231113 215378 214043 210594 208903 207374 207074 200000	203.589 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188	8474.23 8895.25 8895.25 8895.25 8474.23 8474.23 8474.23 8474.23 8474.23 8403.13
4 6 7 5 1 6 7 4	5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5898.31	54977.5 52339.5 52465.7 50715.3 49445.8 47911.4 48126 46419.9 45063 43312.9 44542.2 42024	33050.6 27671.9 26781.6 24345.1 22207.5 19853.8 19552.8 16796.9 14734.6 12748.7 15374.4 12648.2	231322 221720 222831 215085 211398 205557 207562 198396 194219 187717 191994 176742	1144.31 1144.31 899.759 899.759 899.759 899.759 845.037 845.037 845.037 845.037 845.037 845.037	1324.21 1324.21 1035.59 1035.59 1035.59 1035.59 971.187 971.187 971.187 971.187 971.187	54548.2 52233.7 53175.4 56724.3 58966.9 53367.9 57299.1 56103.7 50501.3 51539.8 49331.8 48851.1	2473.31 2479.91 2479.91 2479.91 2479.91 2479.91 2561.02 2561.02 2561.02 2561.02 2561.02 2561.02 2479.91	354,964 354,964 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148	46211.4 45110.2 44606.6 43912.9 43612.4 43239.5 42236.4 41922.3 41185.3 40721.6 39750.9 39917.7	780.63 780.63 630.025 630.025 630.025 630.025 748.669 748.669 748.669 748.669 905.812 905.812	119337 114659 115124 114712 114349 114070 115699 115454 115044 115044 114811 116215 116416	0 0 0 0 0 0 0 0 0 0 0 0 0	9053.52 9495.65 9495.65 9495.65 9495.65 9053.52 9053.52 9053.52 9053.52 9053.52 8976.77	-13703 -15759 -17846 -19225 -20549 -21846 -22957 -24111 -25148 -25999 -26717	11339 11802.2 11769.5 11936.6 10869.7 12325.9 14555.5 14740.9 15594.4 17243.1 17384.3	21775.8 21601 21601 21601 21601 21601 21601 21601 21601 21601 21601 21601 22507	1767.07 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1767.07	0 0 0 0 0 0 0 0 0 0 0	474.449 458.199 437.265 418.106 397.669 392.347 422.789 364.388 343.17 328.481 319.114	625.314 0 65.4976 441.168 310.67 233.677 560.526 374.464 118.009 984.734 310.954	5370.3 5702.97 5993.06 8064.36 10115.3 10045 10782.1 10706.5 11496.1 11886.6 12147.9	2045.18 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2045.18 2045.18	1061.3 1138.01 1138.01 1138.01 1138.01 1192.51 1192.51 1192.51 1192.51 1088.55 1088.55	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1803824 1803894 1805154 1745159 1702787 1651577 1653008 1593364 1546830 1487583 1538376 1444790	160.089 126.383 126.383 126.383 126.383 126.383 118.435 118.435 118.435 118.435 118.435 118.435	215430 223602 231113 215378 214043 210594 208903 207374 207074 200000 196179	203.589 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188	8474.23 8895.25 8895.25 8895.25 8474.23 8474.23 8474.23 8474.23 8474.23 8403.13 8403.13
4 6 7 5 1 6 7 4 2	5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5898.31 5898.31	54977.5 52339.5 52465.7 50715.3 49445.8 47911.4 48126 46419.9 45063 43312.9 44542.2 42024 40401	33050.6 27671.9 26781.6 24345.1 22207.5 19853.8 19552.8 16796.9 14734.6 12748.7 15374.4 12648.2 10785.2	231322 221720 222831 215085 211398 205557 207562 198396 194219 187717 191994 176742 172790	1144.31 1144.31 899.759 899.759 899.759 845.037 845.037 845.037 845.037 845.037 845.037	1324.21 1324.21 1035.59 1035.59 1035.59 1035.59 971.187 971.187 971.187 971.187 971.187	54548.2 52233.7 53175.4 56724.3 58966.9 53367.9 57299.1 56103.7 50501.3 51539.8 49331.8 49331.8 48851.1 44769.5	2473.31 2479.91 2479.91 2479.91 2479.91 2479.91 2561.02 2561.02 2561.02 2561.02 2561.02 2561.02 2479.91 2479.91	354,364 354,964 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148	46211.4 45110.2 44606.6 43912.9 43612.4 43239.5 42236.4 41922.3 41185.3 40721.6 39750.9 39917.7 39432.5	780.63 780.63 630.025 630.025 630.025 630.025 748.669 748.669 748.669 748.669 905.812 905.812	115337 114659 115124 114712 114349 114070 115699 115454 115044 114811 116215 116416 115990	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	9053.52 9495.65 9495.65 9495.65 9053.52 9053.52 9053.52 9053.52 8976.77 8976.77	-13703 -15759 -17846 -19225 -20549 -21846 -22957 -24111 -25148 -25999 -26717 -25802	11339 11802.2 11769.5 11936.6 10869.7 12325.9 14555.5 14740.9 15594.4 17243.1 17384.3 15640.2	21175.8 21601 21601 21601 21601 21601 21601 21601 21601 21601 21601 22507 22507	1767.07 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1767.07 1767.07	0 0 0 0 0 0 0 0 0 0 0 0 0 0	474.449 458.199 437.265 418.106 397.669 392.347 422.789 364.388 343.17 328.481 319.114 310.457	625.314 0 65.4976 441.168 310.67 233.677 560.526 374.464 118.009 984.734 310.954 313.154	5370.3 5702.97 5993.06 8064.36 10115.3 10045 10782.1 10706.5 11496.1 11886.6 12147.9 11564.8	2045.18 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2045.18 2045.18 2045.18	1061.3 1138.01 1138.01 1138.01 1138.01 1132.51 1192.51 1192.51 1192.51 1088.55 1088.55	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1803834 1803834 1805154 1745159 1702787 1651577 1653008 1593364 1593364 1546830 1487583 1538376 1444790 1393735	160.089 126.383 126.383 126.383 126.383 126.383 118.435 118.435 118.435 118.435 118.435 118.435 118.435	215430 223602 231113 215378 214043 210594 208903 207374 207074 200000 196179 193640	203.589 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.589 203.589	8474.23 8895.25 8895.25 8895.25 8474.23 8474.23 8474.23 8474.23 8403.13 8403.13 8403.13
4 6 7 5 1 6 7 4 2 8	5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5898.31 5898.31 5898.31	54977.5 52339.5 52465.7 50715.3 49445.8 47911.4 48419.9 45063 43312.9 44542.2 440401 383223.3	33050.6 27671.9 26781.6 24345.1 22207.5 19853.8 19552.8 16796.9 14734.6 12748.7 15374.4 12648.2 10785.2 8254.25	231322 221720 222831 215085 211398 205557 207562 198396 194219 187717 191994 176742 172790 164372	1144.31 1144.31 899.759 899.759 899.759 845.037 845.037 845.037 845.037 845.037 845.037 845.037 845.037	1324.21 1324.21 1035.59 1035.59 1035.59 1035.59 971.187 971.187 971.187 971.187 971.187 971.187	54548.2 5223.7 53175.4 56724.3 58966.9 53367.9 57299.1 56103.7 50501.3 51539.8 49331.8 44365.5 41431.5	2473.31 2479.91 2479.91 2479.91 2479.91 2479.91 2561.02 2561.02 2561.02 2561.02 2479.91 2479.91 2479.91 2479.91	354,964 354,964 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148 603,148	45211.4 4510.2 44606.6 43912.9 43612.4 43239.5 42236.4 41922.3 41195.3 40721.6 39750.9 39917.7 39432.5 39128.9	780.63 780.63 630.025 630.025 630.025 630.025 748.669 748.669 748.669 905.812 905.812 905.812	115337 114659 115124 114712 114349 114070 115699 115454 115044 114811 116215 116416 115990 115791	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	9053.52 9495.65 9495.65 9495.65 9053.52 9053.52 9053.52 9053.52 9053.52 9053.52 8976.77 8976.77 8976.77	-13703 -15759 -17846 -19225 -20549 -21846 -22957 -24111 -25148 -25939 -26717 -25802 -24794	11339 11802.2 11769.5 11936.6 10869.7 12325.9 14555.5 14740.9 15594.4 17243.1 17384.3 15640.2 14464.2	211775.8 21601 22507 22507 22507 22507 22507	1767.07 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1767.07 1767.07 1767.07	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	474.449 458.199 437.265 418.106 397.669 392.347 422.789 364.388 343.17 328.481 319.114 310.457 301.658	625.314 0 65.4976 441.168 310.67 233.677 560.526 374.464 118.009 984.734 310.954 313.154 258.016	5370.3 5702.97 5993.06 8064.36 10115.3 10045 10782.1 10706.5 11496.1 11886.6 12147.9 11564.8 11195.8	2045.18 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2045.18 2045.18 2045.18	1061.3 1138.01 1138.01 1138.01 1138.01 1192.51 1192.51 1192.51 1192.51 1088.55 1088.55 1088.55		1803834 1805154 1745159 1702787 1651577 1651577 1653008 1593364 1546830 1487583 1538376 144790 1393735 1322812	160.089 126.383 126.383 126.383 126.383 118.435 118.435 118.435 118.435 118.435 118.435 118.435 118.435 118.435	215430 223602 231113 215378 214043 210594 208903 207374 207074 200000 196179 193640 186553	203,589 210,188 210,188 210,188 210,188 210,188 210,188 210,188 210,188 210,188 210,188 210,188 203,589 203,589 203,589	8474.23 8895.25 8895.25 8895.25 8474.23 8474.23 8474.23 8474.23 8474.23 8403.13 8403.13 8403.13
4 6 7 5 1 6 7 4 2 8 3	5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5898.31 5898.31 5898.31	54377.5 5233.5 52465.7 50715.3 49445.8 47311.4 48126 46419.9 45063 43312.9 44542.2 42024 40401 38323.3 38952.7	33050.6 27671.9 26781.6 24345.1 22207.5 19853.8 19552.8 16796.9 14734.6 12748.7 15374.4 12648.2 10785.2 8254.25 2409.21	231322 221720 222831 215085 211398 205557 207562 198396 194219 187717 191994 176742 172790 164372 162093	1144.31 1144.31 899.759 899.759 899.759 845.037 845.037 845.037 845.037 845.037 845.037 845.037	1324.21 1324.21 1035.59 1035.59 1035.59 971.187 971.187 971.187 971.187 971.187 971.187 971.187 971.187	54548.2 5223.7 53175.4 56724.3 58966.9 53367.9 57299.1 56103.7 50501.3 51539.8 49331.8 48851.1 44769.5 41431.5 40782.5	2473.31 2479.91 2479.91 2479.91 2479.91 2561.02 2561.02 2561.02 2561.02 2561.02 2479.91 2479.91 2479.91 2479.91 2479.91 2479.91	354,354 354,964 603,148 603	45110.2 44606.6 43912.9 43612.4 43612.4 43233.5 42236.4 41922.3 41185.3 40721.6 39750.9 39917.7 39432.5 39128.9	780.63 780.63 630.025 630.025 630.025 630.025 748.669 748.669 748.669 748.669 905.812 905.812 905.812 905.812	119337 114659 115124 114712 114349 114070 115699 115454 115044 115044 116215 116416 115990 115791		9053.52 9495.65 9495.65 9495.65 9053.52 9053.52 9053.52 9053.52 9053.52 8976.77 8976.77 8976.77 8976.77	-13703 -13703 -15759 -17846 -19225 -20549 -21846 -22957 -24111 -25148 -25999 -26717 -25802 -24794 -23705	11339 11802.2 11769.5 11936.6 10869.7 12325.9 14555.5 14740.9 15594.4 17243.1 17384.3 15640.2 14464.2	211715.8 21775.8 21601 21601 21601 21601 21601 21601 21601 21601 22507 22507 22507 22507	1767.07 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1767.07 1767.07 1767.07 1767.07 1767.07	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	474.449 458.199 437.265 418.106 397.669 392.347 422.789 364.388 343.17 328.481 319.114 310.457 301.658	625.314 0 65.4976 441.168 310.67 233.677 560.526 374.464 118.009 984.734 310.954 313.154 258.016 258.016	5370.3 5702.97 5993.06 8064.36 10115.3 10045 10782.1 10706.5 11496.1 11886.6 12147.9 11564.8 11195.8 1995.8 11	2045.18 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2045.18 2045.18 2045.18 2045.18	1061.3 1138.01 1138.01 1138.01 1138.01 1192.51 1192.51 1192.51 1088.55 1088.55 1088.55 1088.55		1803824 1803834 1805154 1745159 1702787 1651577 1651577 1653008 1593364 1546830 1487583 1538376 1444790 1393735 1322812 1273758	160.089 126.383 126.383 126.383 126.383 118.435 118.435 118.435 118.435 118.435 118.435 118.435 118.435 118.435 118.435	215430 223602 231113 215378 214043 210594 208903 207374 207074 200000 196179 193640 186553 183561	203.589 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 203.589 203.589 203.589	8474.23 8895.25 8895.25 8895.25 8474.23 8474.23 8474.23 8474.23 8474.23 8403.13 8403.13 8403.13 8403.13 8403.13
4 6 6 7 5 1 1 6 7 4 2 8 3	5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5898.31 5898.31 5898.31 5898.31 5898.31	54377.5 52385.5 52465.7 50715.3 49445.8 47911.4 48126 46419.9 45063 43312.9 44542.2 42024 40401 38323.3 36957.4	33050.6 27671.9 26781.6 24345.1 192207.5 19853.8 19552.8 16796.9 14734.6 12748.7 15374.4 12648.2 10785.2 8254.25 7409.21	231322 221720 222831 215085 211398 205557 207562 198396 194219 187717 191994 176742 172790 164372 164372 164324	1144.31 1144.31 899.759 899.759 899.759 845.037 845.037 845.037 845.037 845.037 845.037 845.037 845.037 845.037	1324.21 1324.21 1035.59 1035.59 1035.59 971.187 971.187 971.187 971.187 971.187 971.187 971.187 971.187 971.187	54548.2 5223.7 53175.4 56724.3 58966.9 53367.9 57299.1 56103.7 50501.3 51539.8 49331.8 48851.1 44769.5 41431.5 40787.5	2473.31 2479.91 2479.91 2479.91 2479.91 2479.91 2561.02 2561.02 2561.02 2561.02 2561.02 2479.91 2479.91 2479.91 2479.91 2479.91 2479.91 2822.28	354,964 354,964 603,148 603	45211.4 45110.2 44606.6 43912.9 43612.4 43612.4 43623.5 42236.4 41922.3 41185.3 40721.6 39750.9 39917.7 39432.5 39128.9 38605.9 2927614	780.63 780.63 630.025 630.025 630.025 748.669 748.669 748.669 748.669 905.812 905.812 905.812 905.812 905.812	115337 114659 115124 114712 114349 114070 115699 115454 115044 115044 116215 116416 115990 115791 115512		9053.52 9495.65 9495.65 9495.65 9053.52 9053.52 9053.52 9053.52 9053.52 8976.77 8976.77 8976.77 8976.77 8976.77	-13703 -15759 -17846 -19225 -20549 -21846 -22957 -24111 -25148 -25999 -26717 -25802 -24794 -2375	11333 11802.2 11769.5 11936.6 10869.7 12325.9 14555.5 14740.9 15594.4 17243.1 17384.3 15640.2 14464.2 12618.2	21775.8 21601 21601 21601 21601 21601 21601 21601 21601 21601 22507 22507 22507 22507 22507	1767.07 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1767.07 1767.07 1767.07 1767.07 1767.07		474.449 458.199 437.265 418.106 397.669 392.347 422.789 364.388 343.17 328.481 319.114 310.457 301.658 292.078	625.314 0 65.4976 441.168 310.67 233.677 560.526 374.464 118.009 984.734 310.954 313.154 258.016 354.879	5370.3 5702.97 5993.06 8064.36 10115.3 10045 10782.1 10706.5 11496.1 11886.6 12147.9 11564.8 11195.8 9958.11 109211	2045.18 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2045.18 2045.18 2045.18 2045.18 2045.18	1061.3 1138.01 1138.01 1138.01 1138.01 1192.51 1192.51 1192.51 1088.55 1088.55 1088.55 1088.55 1088.55 983.244		1803824 1803834 1805154 1745159 1702787 1651577 1653008 1593364 1546830 1487583 1538376 1444790 1393735 1322812 12273758	160.089 126.383 126.383 126.383 126.383 126.383 118.435 118.435 118.435 118.435 118.435 118.435 118.435 118.435 118.435	215430 223602 231113 215378 214043 210594 208903 207374 207074 200000 196179 193640 186553 185551 175400	203.589 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 203.589 203.589 203.589 203.589	8474.23 8895.25 8895.25 8895.25 8474.23 8474.23 8474.23 8474.23 8403.13 8403.13 8403.13 8403.13 8403.13 8403.13 8403.13
4 6 7 5 1 6 7 4 2 8 3 4	5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5161.02 5898.31 5898.31 5898.31 5898.31 5898.31 5898.31	54977.5 52339.5 52465.7 50715.3 49445.8 47911.4 48126 46419.9 45063 43312.9 44542.2 42024 40401 38323.3 36957.7 35434.6	33050.6 27671.9 26781.6 24345.1 22207.5 19853.8 19552.8 16796.9 14734.6 12748.7 15374.4 12648.2 10785.2 8254.25 7409.21 6064.9	231322 221720 222831 215085 211398 205557 207562 198396 194219 187717 191994 176742 172790 164372 162093 154234	1144.31 1144.31 899.759 899.759 899.759 845.037 845.037 845.037 845.037 845.037 845.037 845.037 845.037 845.037 845.037	1324.21 1324.21 1035.59 1035.59 1035.59 1035.59 971.187 971.187 971.187 971.187 971.187 971.187 971.187 971.187 971.187	54548.2 5223.7 53175.4 56724.3 58966.9 57299.1 56103.7 50501.3 51539.8 49331.8 48851.1 44769.5 41431.5 40787.5 44074.9 40512	2473.31 2479.91 2479.91 2479.91 2479.91 2479.91 2561.02 2561.02 2561.02 2561.02 2561.02 2561.02 2479.91 2479.91 2479.91 2479.91 2479.91 2479.91 2479.91 2479.91	354,964 354,964 603,148 603	45211.4 45110.2 44606.6 43912.9 43612.4 43612.4 43239.5 42236.4 41922.3 41185.3 40721.6 39750.9 39917.7 39432.5 39128.9 38605.9 38605.9	780.63 780.63 630.025 630.025 630.025 748.669 748.669 748.669 748.669 905.812 905.812 905.812 905.812 905.812 905.812	119337 114659 115124 114712 114349 114070 115699 115454 115044 115044 116215 116416 115990 115791 115512 115713		9053.52 9495.65 9495.65 9495.65 9053.52 9053.52 9053.52 9053.52 9053.52 8976.77 8976.77 8976.77 8976.77 6727.13 6727.13	-13703 -15759 -17846 -19225 -20549 -21846 -22957 -24111 -25148 -25999 -26717 -25802 -24794 -23705 -22474	11339 11802.2 11802.2 11769.5 11936.6 10869.7 12325.9 14555.5 14740.9 15594.4 17243.1 17384.3 15640.2 14464.2 12618.2 10767.1	211775.8 21601 21601 21601 21601 21601 21601 21601 21601 21601 22507 22507 22507 22507 22507 22507	1767.07 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1767.07 1767.07 1767.07 1767.07 1767.07 1767.07		474.449 458.199 437.265 418.106 397.669 392.347 422.789 364.388 343.17 328.481 319.114 310.457 301.658 292.078 284.272	625.314 0 65.4976 441.168 310.67 233.677 560.526 374.464 118.009 984.734 310.954 313.154 258.016 354.879 213.382 269.097	5370.3 5702.97 5993.06 8064.36 10115.3 10045 10782.1 10706.5 11496.1 11886.6 12147.9 11564.8 11195.8 9958.11 10831.1	2045.18 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2045.18 2045.18 2045.18 2045.18 2045.18	1061.3 1138.01 1138.01 1138.01 1138.01 1192.51 1192.51 1192.51 1088.55 1088.55 1088.55 1088.55 1088.55 983.244 983.244		1803824 1803894 1805154 1745159 1702787 1651577 1653008 1593364 1546830 1487583 1538376 1444790 1393735 1322812 1273758 1221580	160.089 126.383 126.383 126.383 126.383 126.383 118.435 118.435 118.435 118.435 118.435 118.435 118.435 118.435 118.435 118.435	215430 223602 231113 215378 214043 210594 208903 207374 207074 200000 196179 193640 186553 183561 176400	203.589 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 203.589 203.589 203.589 203.589 203.589	8474.23 8895.25 8895.25 8895.25 8474.23 8474.23 8474.23 8474.23 8403.13 8403.13 8403.13 8403.13 8403.13 8403.13 8403.13 6299.4
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4 6 7 5 1 6 7 4 2 8 3 4 2 7 4 1 4 1	5161.02 5163.02 5163.0	54977.5 52385. 52465.7 50715.3 49445.8 47911.4 48126 46419.9 45063 43312.9 44542.2 42024 40401 38323.3 36957.7 35434.4 34263 3301825 32010 31517	33050.6 27671.9 26781.6 24345.1 22207.5 19853.8 19552.8 16796.9 14734.6 12748.7 15374.4 12648.2 10785.2 8254.25 7409.21 6064.9 5310.66 4401.94 4549.4 3909.21 3690.56	231322 221720 222831 215085 211398 205557 207562 198396 194219 187717 191994 176742 172790 164372 162093 154234 149877 143500 145715 140688 139669	1144.31 1144.31 899.759 899.759 899.759 845.037 845.037 845.037 845.037 845.037 845.037 845.037 845.037 845.037 845.037 845.037 845.037 845.037 845.037 845.037	1324.21 1324.21 1035.59 1035.59 1035.59 971.187 971.187 971.187 971.187 971.187 971.187 971.187 971.187 971.187 971.187 971.187 971.187 971.187 971.187 971.187 971.187	54548.2 5223.7 53175.4 56724.3 58966.9 53367.9 57299.1 56103.7 50501.3 51539.8 49331.8 48851.1 44769.5 41431.5 40787.5 440787.5 440787.5 39055.5 39053.3 39053.3	2473.31 2479.91 2479.91 2479.91 2479.91 2479.91 2561.02 2561.02 2561.02 2561.02 2561.02 2561.02 2479.91 2561.02 2562.28 2479.91 2822.28 2822.28 3100 3100 3100 3100	354,964 354,964 603,148 603	45211.4 45110.2 44606.6 43912.9 43912.9 43912.9 43912.9 43923.5 42236.4 41922.3 41185.3 40721.6 39750.9 39917.7 39432.5 39128.9 38750.6 38720.6 38844.8 39378.7 39607.1	780.63 780.63 630.025 630.025 630.025 748.669 748.669 748.669 748.669 748.669 905.812 905.812 905.812 905.812 905.812 905.812 696.853 696.853 696.853 696.853 696.853 819.856 819.856	115337 114659 115124 114712 114349 114070 115699 115454 115044 115990 115791 115512 115713 115666 115625 114205 114567 114890		9053.52 9495.65 9495.65 9495.65 9053.52 9053.52 9053.52 9053.52 9053.52 9053.52 9053.52 9053.52 9053.52 9053.52 907.77 8976.77 8976.77 8976.77 6727.13 6727.13 6727.13 5607.27 5607.27	-13703 -13703 -15759 -17846 -19225 -20549 -21846 -22957 -24111 -25148 -25999 -26717 -25802 -24794 -23705 -24794 -23705 -22474 -21143 -19797 -18379 -17079 -15198	11339 11302.2 11769.5 11936.6 10869.7 12325.9 14555.5 14740.9 15594.4 17243.1 17384.3 15640.2 14464.2 12618.2 10767.1 10856.9 10906.1 12071 12767.1	211775.8 21601 21601 21601 21601 21601 21601 21601 21601 21601 21601 22507 22507 22507 22507 22507 22507 22507 22507 22507 22507 22507	1767.07 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1819.13 1767.07 176		474.449 458.199 437.265 418.106 397.669 392.347 422.789 364.388 343.17 328.481 319.114 310.457 301.658 292.078 284.272 272.422 259.223 236.089 218.775 212.601	625.314 0 65.4976 441.168 310.67 233.677 560.526 374.464 118.009 984.734 310.954 313.154 258.016 354.879 213.382 669.097 235.659 235.659 0 146.465	5370.3 5702.97 5993.06 8064.36 10115.3 10045 10782.1 10706.5 11496.1 11886.6 12147.9 11564.8 11195.8 9958.11 10831.1 9921.42 8285.83 7213.96 7036.2 7413.5	2045.18 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2105.64 2045.18 2045.18 2045.18 2045.18 2045.18 2045.18 2045.18 2045.18 2045.18 2045.18	1061.3 1138.01 1138.01 1138.01 1138.01 1192.51 1192.51 1192.51 1088.55 1088.55 1088.55 1088.55 1088.55 1088.55 983.244 983.244 983.244 983.244 983.244 1267.87 1267.87		1803824 1803834 1805154 1745159 1702787 1651577 1653008 1593364 1546830 1487583 1538376 1444790 1393735 1322812 1273758 1221580 1182175 1139427 1139427 1132194 104800 1089133	160.089 126.383 126.383 126.383 126.383 118.435 118.43	215430 223602 231113 215378 214043 210594 208903 207374 207074 200000 196179 193640 186553 183561 176400 170023 167899 170711 169098 174494	203.589 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 210.188 203.589 203.589 203.589 203.589 203.589 203.589 203.589 203.589 203.589	8474.23 8895.25 8895.25 8895.25 8474.23 8474.23 8474.23 8474.23 8403.13 8403.13 8403.13 8403.13 8403.13 8403.13 8403.13 6299.4 6299.4 6299.4 5252.72 5252.72
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Impact

- Data integrated into Willdan/Integral Analytic's DSMore tool, used for IRP and utility program planning at utilities representing 26 million utility customers
- A consulting firm is using the datasets to inform decarbonization planning for a large utility in the Southeast US

- Several startups using to help large commercial building owners implement carbon reduction plans
- United Power using in design of rebate programs
- NYISO and ISO-NE incorporating into long-term load forecasts for 35 million people
- Alliance to Save Energy using to understand carbon emissions profiles of single-family homes

- CPUC & CA Public Advocates Office using to simulate bill impacts of a rate designed to promote electrification
- Energeia using in a decarbonization study for Washington, DC Office of the People's Counsel
- MN Dept of Commerce using to inform creation of regulatory pathways for natural gas utilities

Currently, the datasets are being used across utility planning, utility rate design, load forecasting, decarbonization planning, and market sizing by entities such as the Minnesota Department of Commerce, the California Public Utility Commission, the New York Independent System Operator, and RMI.

Impact

Consistently #1 most downloads of 2,648 datasets on Open Energy Data Initiative (OEDI) since publication



Impact



Utility Companies:

The results of the EULP research effort will be tremendously helpful to Seattle City Light, allowing us to improve our load modeling of future residential and commercial electrification related to electric vehicles, heat pumps, and other end uses.

Michael Hamilton, Seattle City Light

Building Energy Modeling Industry:

We are excited to help our city and utility clients understand the local impacts of building electrification... with much more confidence than previously available methods such as California DEER or DOE prototype models.

Mudit Saxena, CEO & President, XeroHome / Vistar Energy Inc.

Utility DSM Consultants:

This dataset will be a very valuable resource for the utility demand side management industry.

Justin Spencer Apex Analytics

Technology Developers:

At Lunar Energy, we develop hardware and software products to enable whole-home electrification.

We're excited to engage with this critical dataset to help guide our product direction.

Randol Aikin, Techno Financial Modeling Lead Lunar Energy

Future Work

Increased User Outreach and Documentation

- Feedback from users on technologies to include and data access
- Pre-made reports and tutorials for key use cases
- Data access for common analysis tools (Excel, Python, R, etc.)
- Data access dashboards and summary visualizations
- Expanded comparisons to other data sources (EIA CBECS, EIA Utility Data, etc.) with each release

Comprehensive Set of Upgrades (Measures)

- Expand to cover high-impact energy efficiency, electrification, and demand flexibility technologies
- Biannual releases: EUSS 2023 Release 2 slated for September 2023

Improved Fidelity in Baseline Model and Upgrades

- Improvements to improve natural gas consumption
- Service water heating (for electrification technologies)
- Update and calibrate baseline and upgrades to best available data

Thank You

Performing Organization(s): NREL

PI Name and Title: Andrew Parker, Engineer IV, Commercial Buildings Controls and Analytics Group

PI Tel and/or Email: 303-274-4568, andrew.parker@nrel.gov

WBS #2.5.2.06

REFERENCE SLIDES

ComStock Timeline



Project Execution

Planned Budget		\$	622			1	,223		1,100				
Spent Budget		\$	687			1	.,232		FYTD Feb: \$406				
		FY	2021			F١	/2022		FY2023				
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Past Work													
VizStock 1.1 Release													
Case study using 15-minute timeseries data download				_									
VizStock 1.3 Release													
Technical report of V2 of the commercial stock estimation data integration						_							
VizStock 1.5 Release													
Peer review of definition of building stock differentiable geospatial extents													
Draft Stock Decarbonization Segmentation													
Draft ComStock Documentation													
ComStock Analysis to Support Development of State and Local BPS													
Current Work													
ComStock Progress Report											_		
Draft Technical Assistance Publication												_	
AWS Workflow Demonstration and User Feedback Report													
Novel Sampling Approach Demonstration													
Go / No-Go Decisions:													
Data integration architecture for V2 of stock estimation data integration													
Definition of building stock differentiable geospatial extents.								_					
Segmentation analysis review before impact analysis													
ComStock User Assessment													

Team

- Amy Allen
- Lauren Adams
- Christopher CaraDonna
- Matthew Dahlhausen
- Henry Horsey (Co-PI)
- Janghyun Kim
- Lauren Klun (Project Manager)
- Matt Leach
- Amy LeBar
- Andrew Parker (Co-PI)
- Marlena Praprost
- Korbaga Woldekidan