Measuring Up to Net Zero: The Status of New Construction Programs and How They Can Further Zero Net Energy in the Commercial Sector

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ABSTRACT

In the past few years, Zero Net Energy (ZNE) buildings have gained momentum, with support from U.S. Department of Energy and state energy offices in many climate zones across the United States demonstrating a level of feasibility even in extreme weather. Similarly, there is high participation in utility energy efficiency programs, such as whole building design programs, that encourages high-performance building design through an integrated design process. For some states and utilities, the progress towards ZNE buildings is well-studied and documented; however, for other states, this path isn't so clear.

This paper will analyze historical utility data from three different regions, identify the ZNE potential of the buildings from the data and recommend on how utility incentive programs can be furthered improved to drive deeper energy savings The analysis will examine anonymized new construction program participant data across 10 programs, exploring and assessing the current state of ZNE commercial buildings in three geographic regions: Southwest, Midwest and the Mid-Atlantic.

For each region this paper will assess:

- ZNE policies and market drivers in place for commercial buildings.
- The analysis of program-proposed building energy end-use data and national benchmark data to establish how close to or how far buildings are from achieving ZNE.
- Utility whole building incentive programs (or equivalent) being offered and a comparison of program requirements.
- How the utility incentive programs can be improved to further achieve ZNE goals.

This paper will then provide recommendations to state policymakers and utilities on best practices for state and local policy and utility incentive programs – such as emulating those implemented in California and Massachusetts – and developing more targeted approaches to aid the design and construction industry in promoting promote greater efficiency and ZNE buildings.

Introduction

The data collected and analyzed in this paper are from energy models submitted through utility incentive programs in 2014 and 2015, and reflects a building's predicted energy consumption. Due to the timing of project submissions to each utility's incentive program, the energy usage of the commercial buildings could not be obtained. As a result, only the ZNE "potential" was assessed in this study, and does not reflect real ZNE performance.

In addition to the data collected through utility energy efficiency programs, the authors collected information on state and local energy codes and policies. Due to the need to maintain anonymity in the data collected through utility programs, the results are presented on a regional basis.

Policies & Market Drivers

Today, more than 40 ZNE buildings (International Living Future Institute, 2016) have been built in the United States, with more being designed, providing high energy performance and proving the feasibility of the concept. Aggressive energy reduction policies – like California's "*CPUC Long Term Energy Efficiency Strategic Plan of 2008,"* which proposed that all new commercial construction and 50% of existing commercial buildings to be ZNE by 2030, as well as Massachusetts's *"Clean Energy and Climate Plan for* 2020," that targets 25% greenhouse gas (GHG) reductions by 2020 – are driving the U.S. construction industry to get on and stay on the ZNE building trajectory. The Architecture 2030's "*2030 Challenge,*" which targets carbon-neutrality by 2030 for all new buildings and major renovations, is also widely adopted by numerous cities and counties in North America.

This section will discuss the existing energy efficiency policies and building codes that have been implemented in the Southwest, Midwest and Mid-Atlantic regions of the United States, and how these are creating and influencing ZNE markets. For these three regions, there are no set ZNE policies in place, but all regions have adopted the increasingly stringent International Energy Conservation Code (IECC) as their building energy code.

Utility energy efficiency incentive programs that require building energy code compliance for eligibility can become market drivers for promoting high energy performance in buildings. New construction "Whole Building Design" programs – which require projects to demonstrate total energy savings in a building using an energy model – promote higher energy performance, as compared to prescriptive incentives that are designed for single, stand-alone system energy efficiency. For whole building design programs, a building's total energy is considered for the incentive, so the energy efficiency reduction is predicted holistically using an energy model. Each of the three regions addressed for this paper has a whole building design program, and the data collected from the projects gives us an indication of how they measure up to ZNE status.

Policies and programs are not the only market drivers for ZNE: third-party green building rating systems and demonstration projects also influence market direction. Table 1 lists several contributing factors to the ZNE market for each of the three regions.

Table 1. Comparison of market drivers Net Zero Energy commercial buildings by region

	Southwest	Midwest	Mid-Atlantic
No. of Net Zero Energy Commercial Projects[1]	AZ, NV: 3 buildings (each) CO, TX: 1 building (each) NM, OK, UT, WY: 0 buildings	OH: 2 buildings IN, MN, MO, WI: 1 building (each) IA, IL, KS, MI, ND, NE, SD: 0 buildings	NY, VA: 2 buildings (each) DE: 1 building DC, MD, NJ, PA, WV: 0 buildings
Commercial Sector Energy Use Intensity (thousand Btu/square foot)[2]	494 kBtu/square foot	273kBtu/square foot	290 k Btu/square foot
LEED Green Building Per Capita in the U.S.[3]	CO: 5th NV: 6th TX: 8th UT: 10th AZ, OK, NM, WY: Not ranked in top 10	IL: 1st IA, IN, KS, MI, MN, MO, ND, NE, OH, SD, WI: Not ranked in top 10	DC: Not ranked because it's a federal district MD: 2nd VA: 9th DE, NJ, NY, PA, WV: Not ranked in top 10
Living Building Challenge (Net Zero Energy Certified Projects)	AZ, TX: 1 project (each) CO, UT, NM, NV, OK, WY: 0 projects	MI, MO: 1 project (each) IA, IL, IN, KS, MN, ND, NE, OH, SD, WI: 1 project (IN)	PA, NY: 1 project (each) DC, DE, MD, NJ, VA, WV: 0 projects
Building Energy Codes Adopted[4]	AZ, NV, UT: 2012 IECC NM, OK, TX: 2009 IECC WY: 2006 IECC CO: 2003 IECC	IA, IL, MN,SD: 2012 IECC IN, MI, MO, NE, OH: 2009 IECC KS: 2006 IECC ND: No statewide energy codes	DC: 2013 DC Energy Conservation Code MD, NJ: 2015 IECC DE, NY, VA: 2012 IECC PA, WV: 2009 IECC

The analysis that follows looks at data collected from whole building design utility programs from the three regions. It assesses the ZNE potential of the commercial buildings based on the Zero Energy Performance Index (zEPI) developed by New Buildings Institute (NBI) and which provides a scale for measuring building energy performance. One of the energy benchmark targets on the zEPI scale is a zEPI score of 51, which represents International Green Construction Code (IgCC) 2015- compliant buildings. The IgCC is fully compatible with the International Code Council (ICC) family of codes, and provides "requirements that are intended to reduce the negative impacts and increase the positive impacts of the built environment on the natural environment and building occupants." (International Code Council) The required performance metric in the code is based on the zEPI scale; a compliant building must demonstrate a zEPI score of not more than 51.

[1] Getting to Zero Database, New Buildings Institute.
[2] Site energy use intensity, Commercial Building Energy Consumption Survey (CBECS)
[3] 2015 Top 10 Ranked States for LEED Green Building Per Capita
[4] Status of State Energy Code Adoption, U.S. Department of Energy.

Analysis

Methodology

This paper utilizes data collected from energy models provided to a selection of utility new construction energy efficiency programs. The data is typically provided at the time of initial occupancy, and as a result, likely reflects the anticipated building performance and not the in-operation performance. DNV GL collects data on general building characteristics (building type, area, etc.), energy use by end-use and basic building system information.

In an effort to quantify how close to or far from ZNE each building is, the zEPI was calculated for each project. The following equation from the 2012 IgCC was used to calculate zEPI score for each building – zEPI = 57 x (EUIp/EUIb) – in which EUIp is the source energy intensity of the proposed building and EUIb is the source energy intensity of the ASHRAE 90.1 2007 baseline building.

Using the zEPI rating system allows for the comparison of buildings of different types and geographic regions using a single metric. However knowing the metric alone does not provide any insight to how each building and/or region is progressing towards ZNE.
The Architecture 2030 Challenge was selected as a metric to gauge progress towards ZNE building design in each region. The Challenge was launched in 2006, and established a series of carbon reduction targets resulting in widespread ZNE building design by 2030. Figure 1 shows the five-year targets converted to the zEPI scale by the New Buildings Institute for 2010 through 2030.

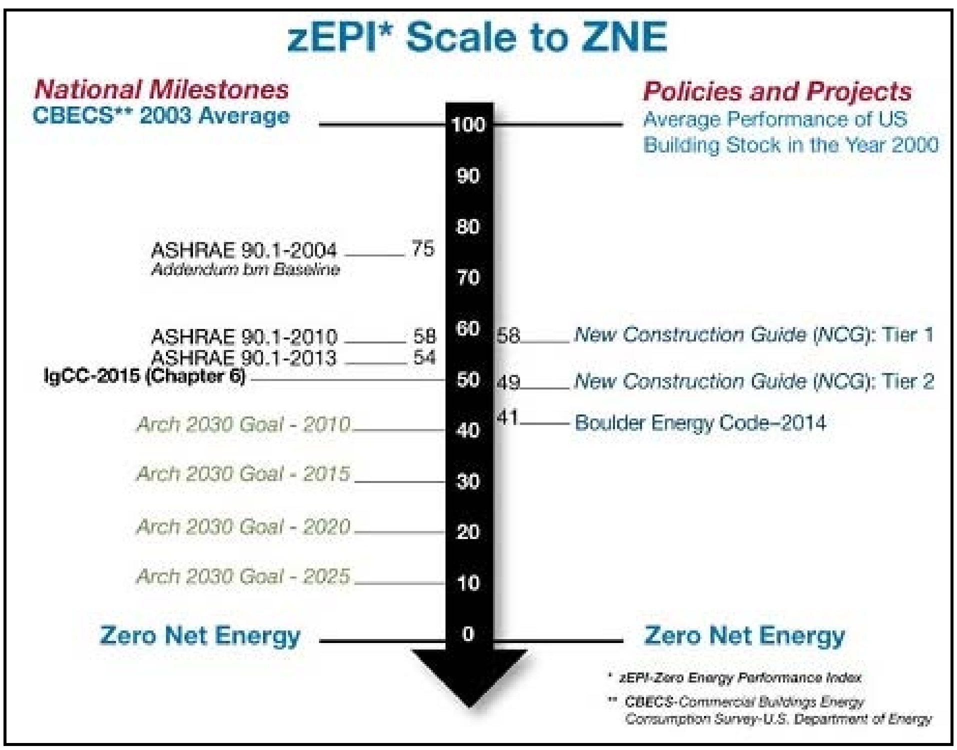

Figure 1. zEPI Scale to ZNE. *Source*: NBI, 2015.

Results

The average project zEPI score for each region over the two-year period remained very consistent, both year-to-year and program-to-program. However, Table 2 shows, the total range in zEPI ratings varied significantly, with buildings ranging from a rating of 23 to 78 for one of the regions. The large spread in zEPI ratings within individual regions potentially indicates opportunities for utility programs to further improve the energy efficiency of many of the buildings participating in their programs.

Table 2. Comparison of average, maximum and minimum zEPI ratings by region

Region	Average zEPI Rating	Max zEPI Rating	Min zEPI Rating	Number of Buildings
Midwest	42	78	23	61
Southwest	42	68	24	24
Mid-Atlantic	47	70	36	17

Source: DNV GL

The analysis could not find any building criteria, such as business type or facility size, that showed any significant correlation to the zEPI rating. A limited number of the programs collected more detailed information on the building systems, such as HVAC system type and lighting power levels. Since only a small number of the programs were able to track this level of detail for each building, the analysis was unable to explore the relationship in any more detail.

As shown in Figures 2 and 3, on average, the buildings in each region roughly meet the Architecture 2030 Challenge goal for 2010 of 40 on the zEPI scale; however, less than 10% of the buildings in any of the regions achieved the Architecture 2030 Challenge goal of 30 for 2015. Since the data collected from the utility new construction programs did not contain information on the renewable energy systems installed at each site, the zEPI rating calculated during this analysis only looks at the building energy consumption and does not include any contributions from renewable energy systems.

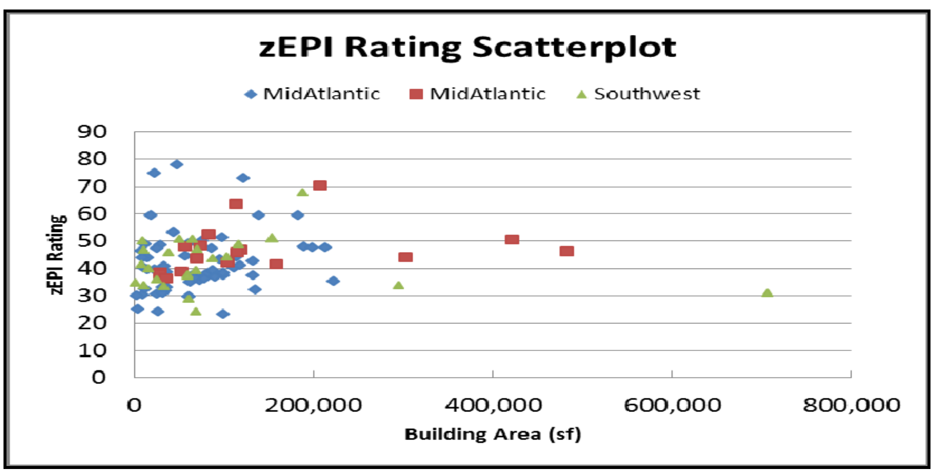

Figure 2. Average quarterly zEPI ratings by region. *Source*: DNV GL

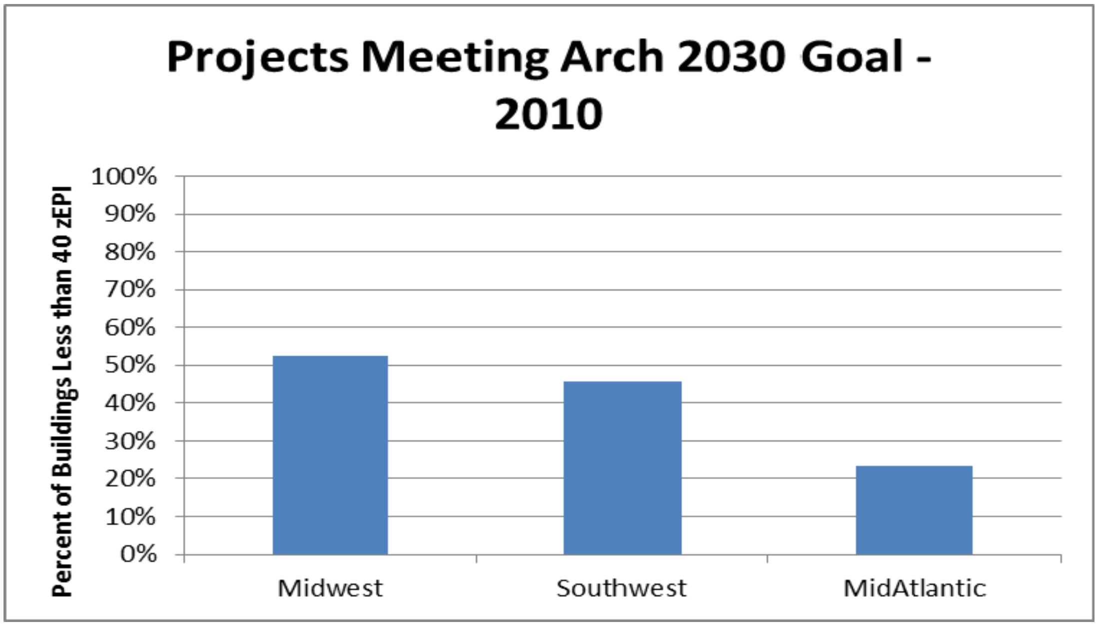

Figure 3. Percentage of buildings in each region that meet Arch 2030 Goal - 2010

This makes the comparison between utility program data and the Arch 2030 Challenge somewhat inconclusive, but does highlight some room for improvement for utility program administrators to integrate energy efficiency and renewable energy programs.

An attempt was made to estimate the renewable energy potential at each of the sites, based on the available roof area and solar energy potential. The analysis showed that a majority of the facilities have enough roof space available to produce energy to achieve ZNE, however given the size of some of the facilities it is likely that a solar installation of that size would be an expensive investment for the owner and not considered economically viable.

To gauge progress in the absence of reliable data on the onsite renewable energy generation, the zEPI score for each building was compared to the performance-based compliance threshold from the 2012 and 2015 International Green Construction Codes. The data showed that 82% to 92% of all buildings in each region achieved the performance-based compliance requirements of both the 2012 and 2015 IgCC, indicating that buildings are achieving significant energy savings.

Further analysis of the data also provided some insight into how the higher-performing buildings are achieving energy savings. Figure 4 presents the average percent savings for each end-use for buildings in each region for higher performing (zEPI score of less than 40) and lower performing (zEPI score of more than 40) buildings.

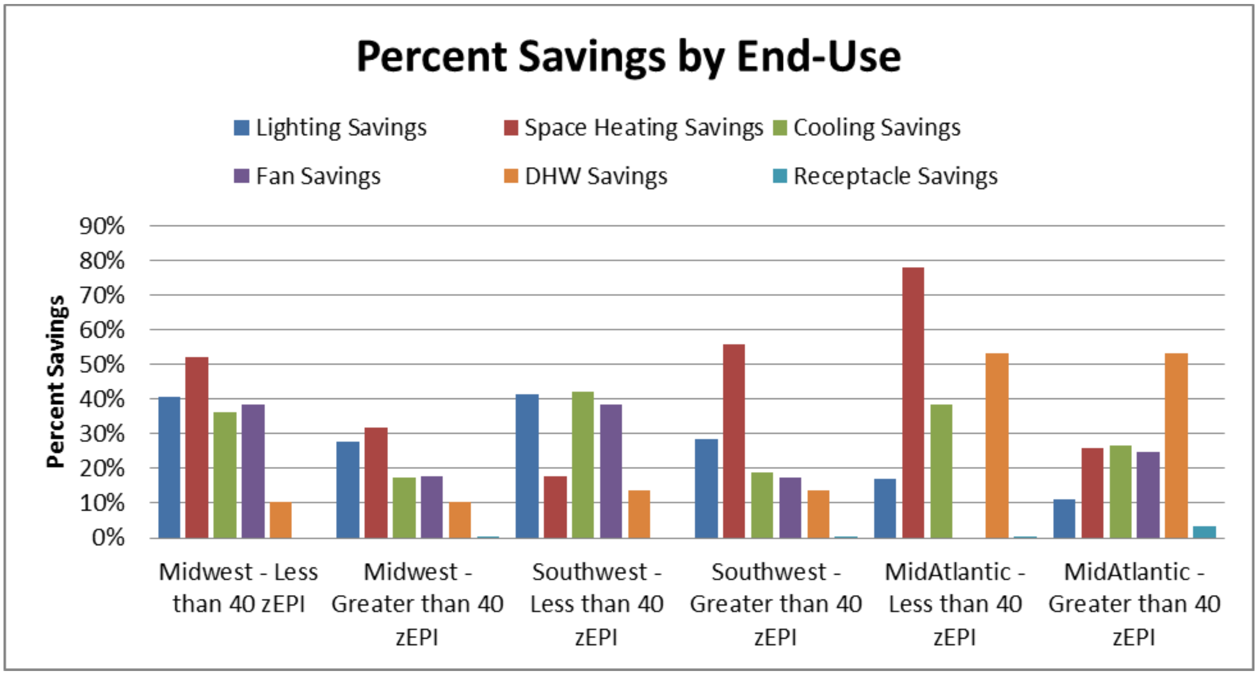

Figure 4. End use savings breakdown by region

Discussion

The results of the analysis show that the majority of the buildings included in the dataset for each region are achieving the minimum efficiency standards of both the 2012 and 2015 IgCC. The IgCC is a green building code that uses a zEPI rating which does not include renewable energy production, making a direct comparison between program data to the IgCC requirements possible. Given the high level of energy efficiency required by the code and the large number of buildings meeting the requirements in all of the regions, the results are a positive indication in the level of energy efficiency incorporated in building stock.

While the two-year timeframe to collect data from utility new construction programs limited the scope of this analysis, it is clear that significant conclusions can be drawn from the data and from the application of green building codes (such as the IgCC) and frameworks (such as the Architecture 2030 Challenge). These conclusions can lead to actionable steps by U.S. utilities seeking to meet ZNE targets.

The analysis did highlight some shortcomings in the data collected by the various utility energy efficiency programs: First, none of the utility programs track any information on renewable energy systems installed at a site, making it difficult to compare the progress for each of the regions to the Architecture 2030 Challenge framework. In an effort to overcome this challenge, an analysis was performed to determine the rooftop solar potential for each building. The analysis showed that for the majority of the facilities, a rooftop solar array could provide sufficient energy to achieve ZNE operation. Given the size of some of the facilities, it is unlikely that a solar installation of that scale would be economically feasible. In order for utility programs to track progress towards ZNE, it will be critical to start collecting data on renewable energy systems in these regions, in addition to building energy consumption.

A majority of the utility programs included in the analysis evaluated the facility energy consumption and savings shortly after initial occupancy. Tracking the on-going performance of a building would provide a much clearer picture of how near or far the facility is from achieving ZNE.

The paper also presents some analysis comparing the percent savings by end-use for higher and lower performing buildings in each region, shown in Figure 4. For the most part, the chart shows expected patterns, such as a higher percent savings for each end-use for higher performing buildings and larger relative heating savings in colder regions. The end-use data was collected from project submittals to each of the utility incentive programs. A key finding from the energy end-use analysis is the lack of savings for receptacle end-uses. While the lack of receptacle savings is not necessarily an indication of high receptacle energy consumption in the buildings, it is an indication of a potential area for utility program providers to provide additional support and incentives. The treatment of receptacle loads in the new construction utility programs included in this study can be divided into two groups:

- Group 1: Prohibits design teams from including savings due to energy efficiency improvements from receptacle or process loads in the program.
- Group 2: Allows for the inclusion of energy savings due to energy efficiency improvements from receptacle or process loads in the program; however, they do not actively promote the process.

Recommendations

In order for each region to meet the Architecture 2030 Challenge, the zEPI scores would need to decrease by two points each year (based on the time-series data currently available) To realize the required year-over-year reductions needed to achieve ZNE construction, the three regions may need to emulate programs implemented in other areas, such as in California and Massachusetts.

The State of California and Commonwealth of Massachusetts have implemented "stretch" or "reach" codes that provide the opportunity for the building industry to have access to and be trained on a more stringent set of energy efficiency requirements than the current building energy code in place. This helps to motivate the market into an early adoption of the more stringent code that may not otherwise happen for another code cycle under the standard building early code.

Currently, there is a proposal to include in the 2018 update of the IECC standard (National Institute of Building Sciences, 2016) an outcome-based pathway for energy compliance, which is already approved to be included in the 2015 IgCC. This outcome-based pathway considers measurement and verification post-occupancy, which is the true metric of how a building is using energy. Considering that all of the states analyzed for this paper have adopted the IECC as their building energy code, these next cycle updates could further propel these regions towards deeper energy efficiency. The approach bases compliance on how buildings use energy once they are constructed, occupied and maintained, which is how ZNE performance of a building is also measured.

In addition, utility incentive programs can be further improved to drive the deeper energy savings required to achieve cost effective ZNE buildings by:

- Developing an alternate compliance path program that uses a more stringent baseline code, such as a stretch code and offers a higher incentive rate on the savings. This will encourage the customer to achieve a higher level of performance.
- Developing an outcome-based performance program that provides incentives based on building's energy post-occupancy.
- Providing targeted training in high performance building design and analysis.
- Identifying and promoting ZNE demonstration projects to raise awareness and show ZNE feasibility.
- Identifying design tools and/or processes to aid design teams and building owners to identify and quantify ZNE enabling technologies and building strategies.
- Providing incentives that cover the perceived market premium for ZNE enabling technologies
- Addressing all building systems, including plug and process loads.

As stated earlier, the results of this paper were limited by the amount of data that could be collected within a two-year window from the new construction utility programs. By collecting more detailed information on building characteristics, renewable energy systems and actual building energy consumption, the analysis could have been expanded significantly and have been able to draw much more conclusive results.

Conclusions

This paper demonstrates some of the potential analysis and insight that can be obtained using data collected from energy models submitted through utility incentive programs. This value could be increased by improved data collection and including such data as:

- Basic building characteristic data, such as HVAC system type and lighting technologies.
- Renewable capacity installed at each site.
- Information on the design process/team.
- In-operation energy and performance data.

Additionally, the paper demonstrated how including tracking metrics, such as the zEPI score for buildings participating in new construction utility programs, can help track progress towards ZNE and establish relative building efficiency compared to more stringent green building codes.

Based on the conclusions that could be drawn from two years' worth of data for the buildings participating in the utility new construction programs, the authors expect reductions in energy consumption to continue that also will lead to the construction of additional ZNE buildings. A number of recommendations for utility program administrators can be made to both promote the development of such buildings – which, in turn, will drive deeper energy savings in such buildings – and to more accurately track the data collected from such projects.

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