ENERGY STAR® PortfolioManager® Technical Reference

ENERGY STAR Score for Vehicle Dealerships in the United States

OVERVIEW

The ENERGY STAR Score for vehicle dealerships applies to buildings used for the sale of new or used light-, medium- and heavy-duty cars and trucks. The objective of the ENERGY STAR score is to provide a fair assessment of the energy performance of a property relative to its peers, considering the climate, weather, and business activities at the property. To identify the aspects of building activity that are significant drivers of energy use and then normalize for those factors, a statistical analysis of the peer building population is performed. The result of this analysis is an equation that will predict the energy use of a property, based on its experienced business activities. The energy use prediction for a building is compared to its actual energy use to yield a 1 to 100 percentile ranking of performance, relative to the national population.

- **Property Types.** The ENERGY STAR Score for vehicle dealerships applies to buildings used for the sale of new or used light-, medium- and heavy-duty cars and trucks.
- **Reference Data.** The analysis for vehicle dealerships is based on data from an industry survey conducted by the National Automobile Dealers Association (NADA) for the 2019 calendar year.
- **Adjustments for Weather and Business Activity.** The analysis includes adjustments for:
    - Number of Workers on the Main Shift
    - Average Number of Vehicles in Inventory
    - Heating and Cooling Degree Days
    - Percent of the Building that is Heated and Cooled
- **Release Date.** The ENERGY STAR score for vehicle dealerships is updated periodically as more recent data becomes available:
    - Most Recent Update: August 2023.

This document presents details on the development of the 1 – 100 ENERGY STAR score for vehicle dealerships. More information on the overall approach to develop ENERGY STAR scores is covered in our Technical Reference for the ENERGY STAR Score, available at www.energystar.gov/ENERGYSTARScore. The subsequent sections of this document offer specific details on the development of the ENERGY STAR score for vehicle dealerships:

REFERENCE DATA & FILTERS

For the ENERGY STAR score for vehicle dealerships, the reference data used to establish the peer building population in the United States is based on data from a United States industry survey conducted by the National Automobile Dealers Association (NADA). EPA relies on publicly available external data sets to develop ENERGY STAR scores where feasible, but a sufficiently robust set of such vehicle dealership energy consumption information was not available. The NADA energy usage survey accounts for the 2019 calendar year and was created for the purpose of creating holistic and robust industry data upon which to base an ENERGY STAR scoring model.

To analyze the building energy and operating characteristics in this survey data, four types of filters are applied to define the peer group for comparison and to overcome any technical limitations in the data: Building Type Filters, Program Filters, Data Limitation Filters, and Analytical Filters. A complete description of each of these categories is provided in our Technical Reference for the ENERGY STAR Score, at www.energystar.gov/ENERGYSTARScore. ***Figure 1*** presents a summary of each filter applied in the development of the ENERGY STAR score for vehicle dealerships, the rationale behind the filter, and the resulting number of properties in the data set after the filter is applied. After all filters are applied, the remaining data set has 104 properties.

Figure 1: Summary of Filters for the ENERGY STAR Score for Vehicle Dealerships

Condition for Including an Observation in the Analysis	Rationale	Number Remaining
Must have complete data* for energy use and operating characteristics	EPA Program Filter – Complete data is necessary for analysis	110
Average Number of Vehicles in Inventory must be less than 25 per 1,000 square feet	Analytical Filter – Values determined to be data entry errors or statistical outliers.	107
Number of Paint Booth Bays + Service Shop Bays + Body Shop Mechanical Bays + Detail Shop Bays must be greater than 0 and less than 1.2 total bays per 1,000 square feet	Analytical Filter – Values determined to be data entry errors or statistical outliers.	106
Must have Parking Adjusted Source EUI greater than 0 and less than 350 kBtu/ft^2	Analytical Filter – Values determined to be data entry errors or statistical outliers.	104

**Energy use data was considered complete if the start date minus end date of primary electricity meter data (i.e., Meter 1) was greater than 330 days and less than 400 days.*

Of the filters applied to the reference data, some result in constraints on calculating a score in Portfolio Manager and others do not. Building Type and Program Filters are used to limit the reference data to include only properties that are eligible to receive a score in Portfolio Manager and are therefore related to eligibility requirements. In contrast, Data Limitation Filters account for limitations in the data availability, but do not apply in Portfolio Manager. Analytical Filters are used to eliminate outlier data points or different subsets of data and may or may not affect eligibility. In some cases, a subset of the data will have different behavior from the rest of the properties (e.g., hotels smaller than 5,000 ft^2 do not behave the same way as larger buildings), in which case an Analytical Filter will be used to determine eligibility in Portfolio Manager. In other cases, Analytical Filters exclude a small number of outliers with extreme values that skew the analysis, but do not affect eligibility requirements. A full description of the criteria you must meet to get a score in Portfolio Manager is available at www.energystar.gov/EligibilityCriteria.

Related to the filters and eligibility criteria described above, another consideration is how Portfolio Manager treats properties that are situated on a campus. The main unit for benchmarking in Portfolio Manager is the property, which may be used to describe either a single building or a campus of buildings. The applicability of the ENERGY STAR score depends on the type of property. For vehicle dealerships, the ENERGY STAR score applies to the entire property, which is itself a unit. Typically, these are properties where it is common to find a campus setting, and where each building on the campus is necessary to make the complete function of the property. For example, the school gym may be in a separate building, but it is inherently part of a school. To receive an ENERGY STAR score, a vehicle dealership it must have gross floor area of at least 5,000 square feet, employ at least one worker during the main shift, and maintain an inventory of at least one vehicle.

Survey Weights

Analysis of the NADA survey data showed that the distribution of facilities across census regions did not reflect the national population. Therefore, rather than being a complete random sample of the population, the survey can be viewed as a stratified random sample, with multiple categories of respondents. In order to properly account for this stratification, survey sample weights were constructed to reflect the probability of being selected within each group. Observations were weighted by census region (i.e., Northeast, Midwest, South, and West). Within each group, the weight of an individual observation was computed as:

$$Observation\ Weight = \frac{Total\ Size\ of\ Population\ in\ Group}{Number\ of\ Responses\ in\ Group}$$

The Total Size of Population in Group was obtained through location data from the Commercial Building Energy Consumption Survey (CBECS) vehicle dealership data. The Number of Responses in Group was counted from the complete set of 112 vehicle dealerships in the survey.

VARIABLES ANALYZED

To normalize for differences in business activity, we perform a statistical analysis to understand what aspects of building activity are significant with respect to energy use. The filtered reference data set described in the previous section is analyzed using a weighted ordinary least squares regression, which evaluates energy use relative to business activity (e.g., employee density, vehicle repair equipment, climate). This linear regression yields an equation that is used to compute energy use (also called the dependent variable) based on a series of characteristics that describe the business activities (also called independent variables). This section details the variables used in the statistical analysis for vehicle dealerships.

Dependent Variable

The dependent variable is what we try to predict with the regression equation. For the vehicle dealership analysis, the dependent variable is energy consumption expressed in source energy use intensity (source EUI). This is equal to the total source energy use of the property divided by the gross floor area. The regressions analyze the key drivers of source EUI – those factors that explain the variation in source energy use per square foot in vehicle dealerships.

Independent Variables

The reference survey collects numerous property operating characteristics that were identified as potentially important for vehicle dealerships. Based on a review of the available variables in the data, in accordance with the criteria for inclusion in Portfolio Manager[1], the following variables were analyzed:

- Gross Floor Area
- Computer Density (Number per 1,000 ft^2)
- Total Bays (Paint + Service + Body +Detail) Density (per 1000 ft^2)
- Vehicle Density (Number per 1,000 ft^2)
- Weekly Operating Hours
- Worker Density (Number per 1,000 ft^2)
- Inventory[2]
- Parking[3]
- Repair Bays[4]
- Space utilization[5]
- Vehicle washing capacity[6]
- Presence of office equipment and appliances[7]
- Number of electric vehicle chargers
- Total irrigated area in square feet.
- Cooling Degree Days (CDD)
- Heating Degree Days (HDD)
- Percent which can be Cooled
- Percent which can be Heated

We perform extensive review on all of these operational characteristics. In addition to reviewing each characteristic individually, characteristics are reviewed in combination with each other (e.g., Heating Degree Days multiplied by Percent which can be Heated). As part of the analysis, some variables are reformatted to reflect the physical relationships of building components. For example, the number of workers is typically evaluated in a density format. The number of workers *per square foot* (not the gross number of workers) is expected to be correlated with the energy use per square foot. The analysis consists of multiple regression formulations. These analyses are structured to find the combination of statistically significant operating characteristics that explain the greatest amount of variance in the dependent variable: source EUI.

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[1] For a complete explanation of these criteria, refer to our Technical Reference for the ENERGY STAR Score, at www.energystar.gov/ENERGYSTARScore.

[2] Multiple variables related to the dealership's inventory including type (new versus used and light-duty versus medium- and heavy-duty) were considered.

[3] Multiple variables related to parking (i.e., highly lit front line parking, open parking, and partially- and fully enclosed parking garages) were considered.

[4] Multiple variables considering the number, size, and operating hours of repair bays, including different combinations of bays in the service shop, body shop, paint shop, and detail shop were considered.

[5] Multiple variables related to the presence operating hours, and percentage of a dealership that is used for customer lounge, food prep, office/showroom/meeting room, and parts storage, were considered.

[6] Multiple variables related to the ability of the dealership to wash vehicles (e.g., number and size of automatic wash stations and mobile wash equipment) were considered.

[7] Multiple variables related to the presence of computers, copiers, printers, servers, and tablets as well as refrigerators, vending machines, and water coolers were considered.

The final regression equation includes the following variables:

- Number of employees on the main shift per 1,000 square feet
- Average Number of Vehicles in Inventory per 1,000 square feet
- Cooling Degree Days × Percent of the Dealership that is Cooled
- Heating Degree Days × Percent of the Dealership that is Heated

These variables are used together to compute the predicted source EUI for vehicle dealerships. The predicted source EUI is the mean EUI for a hypothetical population of buildings that share the same values for each of these variables. That is, the mean energy use for a building that operates just like your building.

Climate Analysis

Climate is one characteristic that was examined closely. EPA analyzed the relationship between EUI and both Cooling Degree Days (CDD) and Heating Degree Days (HDD). A combination of methods was used, which included running regression equations with survey data using various forms and combinations of CDD and HDD. Due to the high correlation between CDD and HDD, EPA determined it was necessary to introduce an engineering adjustment for CDD and HDD into the scoring process. EPA employed an alternative method to account for cooling and heating energy that uses the Department of Energy's commercial reference buildings. These reference buildings use energy modeling to provide complete descriptions of whole building energy use. EPA adjusted the size and loads of the commercial reference buildings to model vehicle dealerships and used models across a range of climate zones to identify the relationships between heating energy and HDD, and cooling energy and CDD in the modeled data.

Testing

Finally, we test the regression equation using actual vehicle dealerships that have been entered in Portfolio Manager. This provides another set of buildings to examine in addition to the NADA survey data, to see the average ENERGY STAR scores and distributions, and to assess the impacts and adjustments. This analysis provides a second level of confirmation that the final regression equation produces robust results that are unbiased with respect to the key operational characteristics such as number of workers, vehicle density, heating degree days and cooling degree days.

It is important to reiterate that the final regression equation is based on the nationally representative reference data, not data previously entered into Portfolio Manager.

REGRESSION EQUATION RESULTS

The final regression is a weighted ordinary least squares regression across the filtered data set of 104 observations. The dependent variable is source EUI. Each independent variable is centered relative to the mean value, presented in ***Figure 2***. The final equation is presented in ***Figure 3***. All variables in the regression equation are significant at the 95% confidence level or better, as shown by the significance levels (a p-level of less than 0.05 indicates 95% confidence).

The regression equation has a coefficient of determination (R^2) value of 0.2285, indicating that this equation explains 22.85% of the variance in source EUI for vehicle dealerships. Because the final equation is structured with energy per square foot as the dependent variable, the explanatory power of square foot is not included in the R^2 value, thus

this value appears artificially low. Re-computing the R^2 value in units of source energy[8] demonstrates that the equation actually explains 47.94% of the variation of source energy of vehicle dealerships.

Detailed information on the ordinary least squares regression approach is available in our Technical Reference for the ENERGY STAR Score, at www.energystar.gov/ENERGYSTARScore.

Figure 2 - Descriptive Statistics for Variables in Final Regression Equation

Variable	Mean	Minimum	Maximum
Source EUI (kBtu/ft^2)	147.2	15.7	321.1
Number of employees on the main shift per 1,000 ft2	1.680	0.4375	3.387
Average Number of Vehicles in Inventory per 1,000 ft2	7.551	0.2656	20.51
Cooling Degree Days × Percent Cooled	1557	21.23	4725
Heating Degree Days × Percent Heated	3607	0	9816

Figure 3 - Final Regression Result

Summary				
Dependent Variable		Source Energy Use Intensity (kBtu/ft^2)		
Number of Observations in Analysis		104		
R^2 value		0.2285		
Adjusted R^2 value		0.2133		
F Statistic		14.96		
Significance (p-level)		< 0.0001		
	Unstandardized Coefficients	**Standard Error**	**T value**	**Significance (p-level)**
Constant	147.2	5.530	26.62	< 0.0001
C_Number of employees on the main shift per 1,000 square feet	25.04	9.521	2.630	0.009873
C_Average Number of Vehicles in Inventory per 1,000 square feet	2.628	1.201	2.188	0.03095
C_Cooling Degree Days × Percent Cooled	0.01039	0	Infty	< 0.0001
C_Heating Degree Days × Percent Heated	0.003730	0	Infty	< 0.0001

Notes:

- *The regression is a weighted ordinary least squares regression, weighted by the Survey Weights (refer to Survey Weights Section)*
- *The prefix C_ on each variable indicates that it is centered. The centered variable is equal to difference between the actual value and the observed mean. The observed mean values are presented in **Figure 2**.*
- *The CDD and HDD coefficients were restricted to the average kBtu/ft^2 for CDD, and HDD identified through the analysis of the Department of Energy's Commercial Building Reference Data (refer to the Climate Variables Section)*

[8] The R^2 value in Source Energy is calculated as: 1 – (Residual Variation of Y) / (Total Variation of Y). The residual variation is sum of (Actual Source Energy$_i$ – Predicted Source Energy$_i$)^2 across all observations. The Total variation of Y is the sum of (Actual Source Energy$_i$ – Mean Source Energy)^2 across all observations.

ENERGY STAR SCORE LOOKUP TABLE

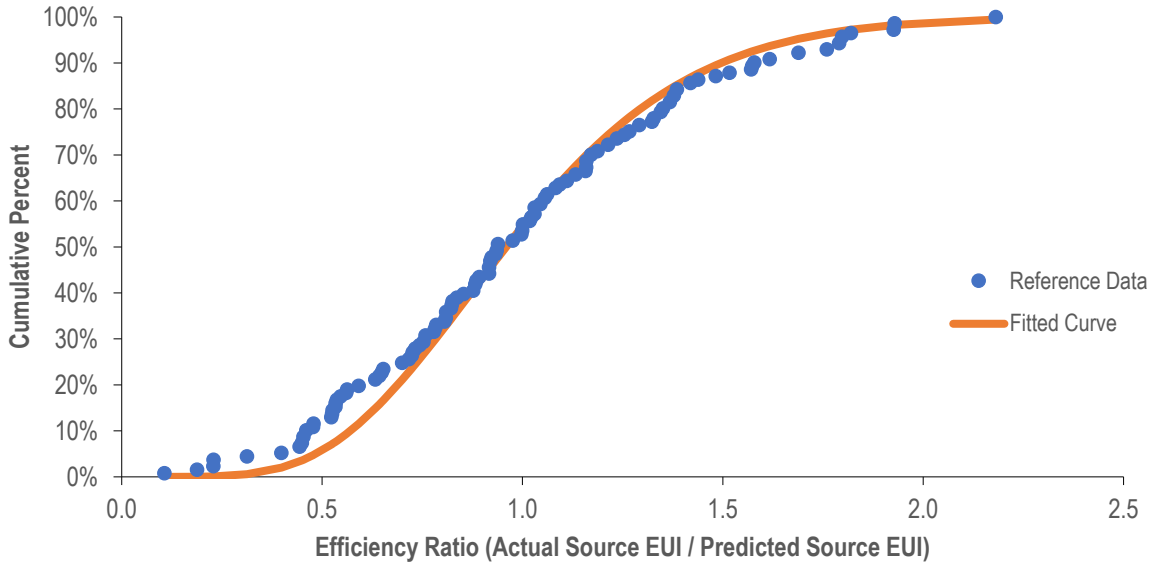
Some buildings in the reference data sample use more energy than predicted by the regression equation, while others use less. The *actual* source EUI of each reference data observation is divided by its *predicted* source EUI to calculate an energy efficiency ratio. The final regression equation (presented in ***Figure 3***) yields a prediction of source EUI based on a building's operating characteristics.

$$Energy\ Efficiency\ Ratio = \frac{Actual\ Source\ EUI}{Predicted\ Source\ EUI}$$

A lower efficiency ratio indicates that a building uses less energy than predicted, and consequently is more efficient. A higher efficiency ratio indicates the opposite.

The efficiency ratios are sorted from smallest to largest and the cumulative percent of the population at each ratio is computed using the individual observation weights from the reference data set. ***Figure 4*** presents a plot of this cumulative distribution. A smooth curve (shown in orange) is fitted to the data using a two-parameter gamma distribution. The fit is performed in order to minimize the sum of squared differences between each building's actual percent rank in the population and each building's percent rank with the gamma solution. The final fit for the gamma curve yielded a shape parameter (alpha) of 7.428 and a scale parameter (beta) of 0.1352. For this fit, the sum of the squared error is 0.1083.

Figure 4 - Distribution for Vehicle Dealerships



The final gamma shape and scale parameters are used to calculate the efficiency ratio at each percentile (1 to 100) along the curve. For example, the ratio on the gamma curve at 1% corresponds to a score of 99; only 1% of the population has a ratio this small or smaller. The ratio on the gamma curve at the value of 25% will correspond to the ratio for a score of 75; only 25% of the population has ratios this small or smaller. The complete score lookup table is presented in ***Figure 5***.

Figure 5 – ENERGY STAR Score Lookup Table for Vehicle Dealerships

ENERGY STAR Score	Cumulative Percent	Energy Efficiency Ratio ≥	Energy Efficiency Ratio <
100	0%	0.0000	0.3478
99	1%	0.3478	0.3984
98	2%	0.3984	0.4331
97	3%	0.4331	0.4606
96	4%	0.4606	0.4839
95	5%	0.4839	0.5044
94	6%	0.5044	0.5228
93	7%	0.5228	0.5397
92	8%	0.5397	0.5554
91	9%	0.5554	0.5702
90	10%	0.5702	0.5841
89	11%	0.5841	0.5974
88	12%	0.5974	0.6101
87	13%	0.6101	0.6223
86	14%	0.6223	0.6341
85	15%	0.6341	0.6455
84	16%	0.6455	0.6566
83	17%	0.6566	0.6675
82	18%	0.6675	0.6780
81	19%	0.6780	0.6883
80	20%	0.6883	0.6985
79	21%	0.6985	0.7084
78	22%	0.7084	0.7182
77	23%	0.7182	0.7278
76	24%	0.7278	0.7373
75	25%	0.7373	0.7467
74	26%	0.7467	0.7560
73	27%	0.7560	0.7652
72	28%	0.7652	0.7743
71	29%	0.7743	0.7833
70	30%	0.7833	0.7923
69	31%	0.7923	0.8012
68	32%	0.8012	0.8101
67	33%	0.8101	0.8189
66	34%	0.8189	0.8277
65	35%	0.8277	0.8364
64	36%	0.8364	0.8452
63	37%	0.8452	0.8539
62	38%	0.8539	0.8626
61	39%	0.8626	0.8713
60	40%	0.8713	0.8800
59	41%	0.8800	0.8887
58	42%	0.8887	0.8974
57	43%	0.8974	0.9062
56	44%	0.9062	0.9149
55	45%	0.9149	0.9237
54	46%	0.9237	0.9326
53	47%	0.9326	0.9414
52	48%	0.9414	0.9503
51	49%	0.9503	0.9593
50	50%	0.9593	0.9683
49	51%	0.9683	0.9774
48	52%	0.9774	0.987
47	53%	0.987	0.996
46	54%	0.996	1.005
45	55%	1.005	1.014
44	56%	1.014	1.024
43	57%	1.024	1.034
42	58%	1.034	1.043
41	59%	1.043	1.053
40	60%	1.053	1.063
39	61%	1.063	1.073
38	62%	1.073	1.083
37	63%	1.083	1.094
36	64%	1.094	1.104
35	65%	1.104	1.115
34	66%	1.115	1.126
33	67%	1.126	1.137
32	68%	1.137	1.148
31	69%	1.148	1.160
30	70%	1.160	1.172
29	71%	1.172	1.184
28	72%	1.184	1.196
27	73%	1.196	1.209
26	74%	1.209	1.222
25	75%	1.222	1.235
24	76%	1.235	1.249
23	77%	1.249	1.264
22	78%	1.264	1.278
21	79%	1.278	1.294
20	80%	1.294	1.310
19	81%	1.310	1.326
18	82%	1.326	1.344
17	83%	1.344	1.362
16	84%	1.362	1.381
15	85%	1.381	1.401
14	86%	1.401	1.422
13	87%	1.422	1.445
12	88%	1.445	1.469
11	89%	1.469	1.495
10	90%	1.495	1.524
9	91%	1.524	1.556
8	92%	1.556	1.591
7	93%	1.591	1.630
6	94%	1.630	1.677
5	95%	1.677	1.732
4	96%	1.732	1.801
3	97%	1.801	1.896
2	98%	1.896	2.053
1	99%	2.053	>2.053

EXAMPLE CALCULATION

As detailed in our Technical Reference for the ENERGY STAR Score, at www.energystar.gov/ENERGYSTARScore, there are five steps to compute a score. The following is a specific example for the score for vehicle dealerships:

1 User enters building data into Portfolio Manager

- 12 months of energy use information for all energy types (annual values, entered in monthly meter entries)
- Physical building information (size, location, etc.) and use details describing building activity (number of workers, etc.)

Energy Data	Value
Electricity	439,625 kWh
Natural gas	12,000 therms

Property Use Details	Value
Gross Floor Area	50,000
Number of Workers on Main Shift	70
Number of Vehicles in Inventory	250
Heating Degree Days	3663
Cooling Degree Days	1904
Percent of the Building that is Heated	100
Percent of the Building that is Cooled	100

2 Portfolio Manager computes the actual source EUI

- Total energy consumption for each fuel is converted from billing units into site energy and source energy.
- Source energy values are added across all fuel types.
- Source energy is divided by gross floor area to determine actual source EUI.

Computing Actual Source EUI

Fuel	Billing Units	Site kBtu Multiplier	Site kBtu	Source kBtu Multiplier	Source kBtu
Electricity	439,625 kWh	3.412	1,500,000	2.80	4,200,000
Natural gas	12,000 therms	100	1,200,000	1.05	1,260,000
				Total Source Energy (kBtu)	5,460,000
				Actual Source EUI (kBtu/ft²)	**109.2**

3 Portfolio Manager computes the predicted source EUI

- Using the property use details from Step 1, Portfolio Manager computes each building variable value in the regression equation (determining the natural log or density or applying any minimum or maximum values used in the regression model, as necessary).
- The centering values are subtracted to compute the centered variable for each operating parameter.
- The centered variables are multiplied by the coefficients from the regression equation to obtain a predicted source EUI.

Computing Predicted Source EUI

Variable	Actual Building Value	Reference Centering Value	Building Centered Variable	Coefficient	Coefficient × Centered Variable
Constant	-	-	1.000	147.2	147.2
Number of employees on the main shift per 1,000 Square Feet	*1.400*	1.680	-0.2800	25.04	-7.011
Average Number of Vehicles in Inventory per 1,000 square feet	*5.000*	7.551	-2.551	2.628	-6.704
Cooling Degree Days × Percent of the Dealership that is Cooled	*3663*	1557	2106	0.01039	21.88
Heating Degree Days × Percent of the Dealership that is Heated	*1904*	3644	-1740	0.003730	-6.490
				Predicted Source EUI (kBtu/ft²)	**148.9**

4 Portfolio Manager computes the energy efficiency ratio

- The energy efficiency ratio equals the actual source EUI (Step 2) divided by predicted source EUI (Step 3)
- Energy Efficiency Ratio = 109.2 / 148.9 = 0.7335

5 Portfolio Manager uses the efficiency ratio to assign a score via a lookup table

- The energy efficiency ratio from Step 4 is used to identify the score from the lookup table.
- An energy efficiency ratio of 0.7335 is greater than or equal to 0.7278 and less than 0.7373.
- ***The ENERGY STAR score is 76.***