INST 327, Section: 0201

Electric Vehicle Population

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Introduction

In recent years, electric vehicles have become more popular and common among car users and buyers. The sales of electric cars have exponentially increased and exceeded 10 million in 2022. These sales tripled in three years from it being 4% in 2020 and 14% in 2022. It is predicted that electric cars will account for 18% of total car sales across the full calendar year and this means that the need for 5 million barrels of oil a day will be avoided by 2030. Electric vehicles have seen a recent popularity because they use clean energy. This aids in decarbonising road transport, which accounts for one-sixth of global emissions. With the current climate crisis, the use of electric vehicles is a way to reduce gas emissions. With that in mind, Our team decided to create a database that holds information about Electric vehicles and their contribution to the environment.

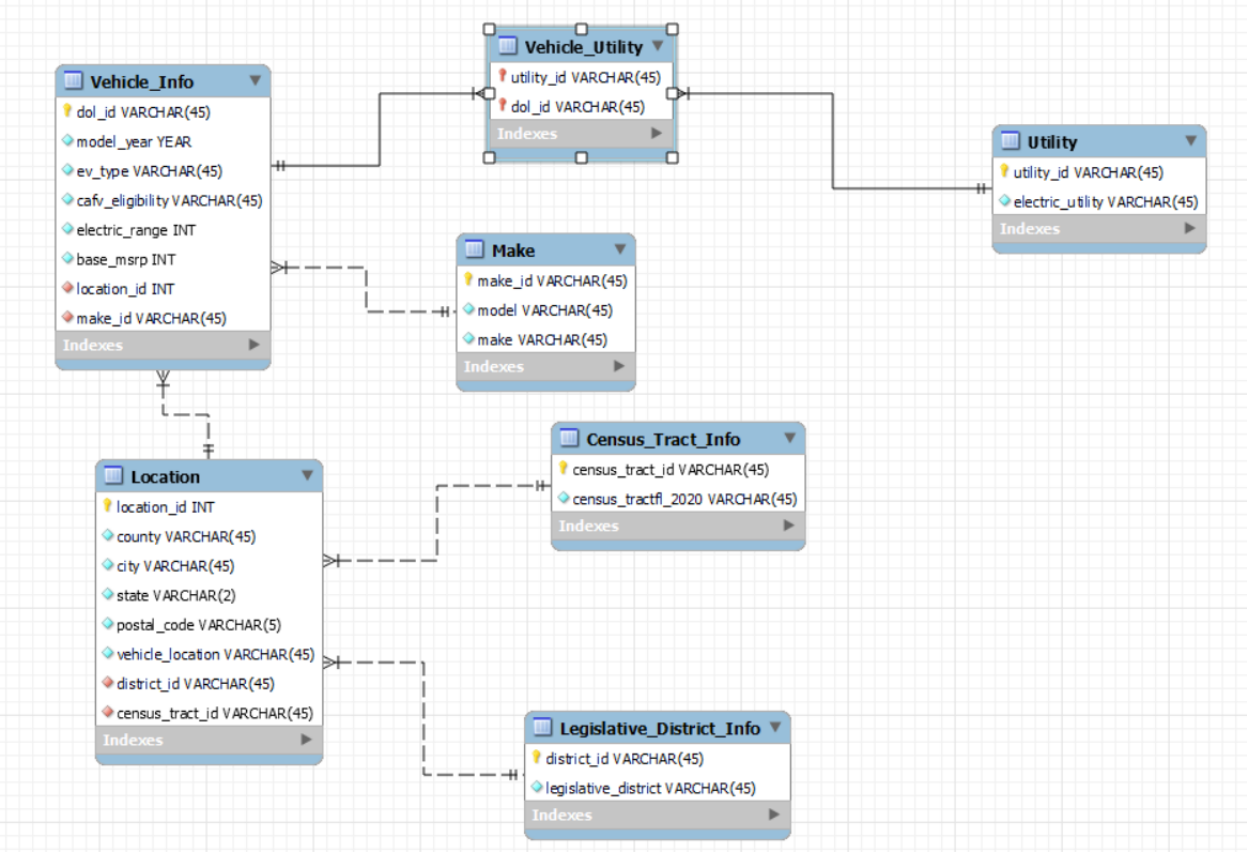
With this new database of electric vehicles and their capabilities and attributes we are able to gain insightful information about the type of vehicles and their geographical location facilitating a deeper understanding of EV adoption patterns, charging infrastructure needs, and opportunities to target interventions to promote sustainable transportation. Additionally by leveraging data analytics and a visualization of dataset, we can uncover trends and correlations between EV relations, demographic factors, and environmental considerations to make decisions to support the growth of the electric vehicle ecosystem.

Database Description

Our database on Electric vehicles covers several attributes regarding the electric vehicle population in the state of Washington. We cover data on the electric vehicles in each city as well as each county, the makes and models of these vehicles and their types are also covered. We use attributes that are relevant to the topic of gas emissions and their effect on climate change. Because electric vehicles are safer for the environment, we included attributes such as their electric range, their eligibility for being clean alternative vehicles (CAVF), and their utility availability in our database. For more information on the financial aspect, we included the attribute of the Manufacturer's suggested retail price (MSRP) as well. With a collection of these

attributes our audience, which can vary such as automotive companies, buyers, environmentalists, etc. can get specific insights that could benefit their knowledge of the electric vehicle population. It could also provide a proficient analysis of market trends related to EV adoption like sales figures, charging infrastructure, future demand, and consumer choices. We have chosen the topic of electric vehicle population because as the world turns to alternative energy EVs are the next big thing. Electric vehicles improve fuel economy, reduce emissions, and lower maintenance costs.

Logical Design



Our dataset required that we created a logical design set that is comprehensive, informative, and easy to use for those who have access. We chose to include seven descriptive tables into our final design form that we believe would be the most beneficial in analyzing the market trends of the "Electric Vehicle Population." We started the process of determining the information pertaining to the vehicles present (model year, vehicle type, clean alternative fuel vehicles, vehicle battery range, and Base MSRP), make, location, utility, etc., and splitting them

into separate groups. After going through the three normalization processes, we used the sets that we made in the third form to finalize the look of our Entity Relationship Diagram. Our basis, when designing, was created with the notion of us being able to pull and read information from a very large database supporting a widely diverse set of information.

Physical Design

Our database has been crafted for individuals interested in electric vehicles across the state of Washington. Our model consists of seven total tables. The Vehicle_Information table, forming the central hub, connects through one-to-many relationships to several other tables, enhancing data richness. This includes a link to the Location table, which incorporates Census_Tract and Legislative_District_Info, providing users with precise regional information crucial for decision-making. We've also integrated the Make and Utility tables, which deliver extensive details on the vehicles and the services available. Relationships within the database are categorized into identifying, where utility and vehicle are interdependent, and non-identifying, which allows associated entities like charging stations and service centers to exist independently yet provide enriched contextual data. This structured approach enables comprehensive analysis and accessibility of EV-related data across Washington.

Sample Data

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Vehicle Identification Number (1-10)	County	City	State	Postal Code	Model Year	Make	Model	Electric Vehicle Type	Clean Alternative Fuel Vehicle (CAFV) Eligibility	Electric Range	Base MSRP	Legislative District	DOL Vehicle ID	Vehicle Location	Electric Utility	2020 Census Tract
2	1C4JJXP60M	Spokane	Spokane	WA	99217	2021	JEEP	WRANGLER	Plug-in Hybrid Electric Vehicle (PHEV)	Not eligible due to low battery range	25	0	6	154994794	POINT (-117.37056 47.70402)	INLAND POWER & LIGHT COMPANY	53063011204
3	1FADP3R40D	Benton	Richland	WA	99352	2013	FORD	FOCUS	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	76	0	8	164564977	POINT (-119.27372 46.27391)	CITY OF RICHLAND - (WA)	53005010810
4	1G1FW6S00H	Franklin	Pasco	WA	99301	2017	CHEVROLET	BOLT EV	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	238	0	9	144434748	POINT (-119.09467 46.23542)	BONNEVILLE POWER ADMINISTRATION	53021020501
5	1G6RL1E40G	Thurston	Rochester	WA	98579	2016	CADILLAC	ELR	Plug-in Hybrid Electric Vehicle (PHEV)	Clean Alternative Fuel Vehicle Eligible	40	0	35	161629142	POINT (-123.08743 46.82175)	PUGET SOUND ENERGY INC	53067012610
6	1N4AZ0CP0D	Walla Walla	Walla Walla	WA	99362	2013	NISSAN	LEAF	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	75	0	16	238926481	POINT (-118.34261 46.07068)	PACIFICORP	53071920902
7	2C4RC1H71K	Pierce	Lakewood	WA	98499	2019	CHRYSLER	PACIFICA	Plug-in Hybrid Electric Vehicle (PHEV)	Clean Alternative Fuel Vehicle Eligible	32	39995	29	350302242	POINT (-122.51495 47.16195)	PENINSULA LIGHT COMPANY	53053071807
8	3C3CFFGE0D	King	Seattle	WA	98112	2013	FIAT	500	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	87	0	43	202116554	POINT (-122.30716 47.62687)	CITY OF SEATTLE - (WA)	53033007600
9	4JGDA6DB1J	King	Kirkland	WA	98034	2018	MERCEDES-BENZ	GLE-CLASS	Plug-in Hybrid Electric Vehicle (PHEV)	Not eligible due to low battery range	8	0	1	223904964	POINT (-122.22901 47.72201)	CITY OF TACOMA - (WA)	53033022300
10	537LS7D41B	Whatcom	Bellingham	WA	98229	2011	AZURE DYNAMICS	TRANSIT CONNECT ELECTRIC	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	56	0	40	168848459	POINT (-122.45516 48.74487)	PUD NO 1 OF WHATCOM COUNTY	53073000700
11	5LMTJ5DZ0N	Snohomish	Edmonds	WA	98026	2022	LINCOLN	CORSAIR	Plug-in Hybrid Electric Vehicle (PHEV)	Not eligible due to low battery range	28	0	21	219118266	POINT (-122.31768 47.87166)	PUD 1 OF SNOHOMISH COUNTY	53061042003
12	5UXKT0C30H	Spokane	Spokane	WA	99223	2017	BMW	X5	Plug-in Hybrid Electric Vehicle (PHEV)	Not eligible due to low battery range	14	0	6	193421448	POINT (-117.36043 47.63396)	AVISTA CORP	53063004900
13	5YJ3E1EA0J	Kittitas	Cle Elum	WA	98922	2018	TESLA	MODEL 3	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	215	0	13	321527790	POINT (-120.93943 47.195)	CITY OF CHENEY - (WA)	53037975201
14	7JRBR0FL1N	Pierce	Orting	WA	98360	2022	VOLVO	S60	Plug-in Hybrid Electric Vehicle (PHEV)	Not eligible due to low battery range	22	0	2	187956604	POINT (-122.20166 47.09596)	PUD NO 1 OF OKANOGAN COUNTY	53053070404
15	JA3215H1XC	Benton	Kennewick	WA	99336	2012	MITSUBISHI	I-MIEV	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	62	0	8	198039824	POINT (-119.11698 46.20804)	PUD NO 1 OF BENTON COUNTY	53005010901
16	JF2GTDNC1K	Walla Walla	Walla Walla	WA	99362	2019	SUBARU	CROSSTREK	Plug-in Hybrid Electric Vehicle (PHEV)	Not eligible due to low battery range	17	34995	16	176473860	POINT (-118.34261 46.07068)	CITY OF ELLENSBURG - (WA)	53071920902
17	JHMZC5F10J	King	Bellevue	WA	98007	2018	HONDA	CLARITY	Plug-in Hybrid Electric Vehicle (PHEV)	Clean Alternative Fuel Vehicle Eligible	47	0	48	214871184	POINT (-122.12053 47.61334)	PUD NO 1 OF KLICKITAT COUNTY	53033023000
18	JTDKARFP4J	Whatcom	Bellingham	WA	98226	2018	TOYOTA	PRIUS PRIME	Plug-in Hybrid Electric Vehicle (PHEV)	Not eligible due to low battery range	25	0	42	229621276	POINT (-122.49756 48.7999)	CITY OF CHEWELAH	53073010600
19	JTJHKCFZ4N	Spokane	Spokane	WA	99224	2022	LEXUS	NX	Plug-in Hybrid Electric Vehicle (PHEV)	Clean Alternative Fuel Vehicle Eligible	37	0	6	198781068	POINT (-117.46996 47.59431)	PORTLAND GENERAL ELECTRIC CO	53063013503
20	KM8K33AG0L	Thurston	Lacey	WA	98516	2020	HYUNDAI	KONA	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	258	0	22	102794268	POINT (-122.75379 47.06316)	PUD NO 1 OF JEFFERSON COUNTY	53067012225
21	KNAGV4LD1J	Clark	Vancouver	WA	98660	2018	KIA	OPTIMA	Plug-in Hybrid Electric Vehicle (PHEV)	Not eligible due to low battery range	29	0	49	163213900	POINT (-122.67156 45.63248)	PUD NO 1 OF CLARK COUNTY - (WA)	53011041005
22	LPSED3KA0M	Clark	Vancouver	WA	98664	2021	POLESTAR	PS2	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	233	0	49	172841931	POINT (-122.59219 45.62158)	PUD NO 1 OF KITTITAS COUNTY	53011041208
23	SADHD2S10K	Mason	Shelton	WA	98584	2019	JAGUAR	I-PACE	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	234	0	35	143799533	POINT (-123.10565 47.21248)	PUD NO 1 OF MASON COUNTY	53045960500
24	SALWV2RYXL	King	Redmond	WA	98053	2020	LAND ROVER	RANGE ROVER SPORT	Plug-in Hybrid Electric Vehicle (PHEV)	Not eligible due to low battery range	19	0	45	122417998	POINT (-122.03287 47.68555)	BIG BEND ELECTRIC COOP, INC	53033032313
25	SJAAJ2ZV4L	Snohomish	Mukilteo	WA	98275	2020	BENTLEY	BENTAYGA	Plug-in Hybrid Electric Vehicle (PHEV)	Not eligible due to low battery range	18	0	21	122018970	POINT (-122.29196 47.89908)	COLUMBIA RURAL ELEC ASSN, INC	53061042006
26	WA12AAGE2M	Thurston	Olympia	WA	98501	2021	AUDI	E-TRON SPORTBACK	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	218	0	35	147198446	POINT (-122.89166 47.03956)	PUD NO 1 OF DOUGLAS COUNTY	53067011721
27	WMEEJ9AA9D	Pierce	Tacoma	WA	98403	2013	SMART	FORTWO ELECTRIC DRIVE	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	68	0	27	203615086	POINT (-122.45691 47.26496)	CITY OF PORT ANGELES - (WA)	53053061502
28	WMZYU7C59K	Grays Harbor	Hoquiam	WA	98550	2019	MINI	COUNTRYMAN	Plug-in Hybrid Electric Vehicle (PHEV)	Not eligible due to low battery range	12	36900	24	205042432	POINT (-123.88689 46.97982)	PUD NO 1 OF GRAYS HARBOR COUNTY	53027001400
29	WP0AC2Y13M	Clark	Battle Ground	WA	98604	2021	PORSCHE	TAYCAN	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	192	0	18	179261218	POINT (-122.5331 45.78092)	VERA IRRIGATION DISTRICT #15	53011040416
30	WVWKP7AU0G	Skagit	Anacortes	WA	98221	2016	VOLKSWAGEN	E-GOLF	Battery Electric Vehicle (BEV)	Clean Alternative Fuel Vehicle Eligible	83	0	40	154035290	POINT (-122.61214 48.51748)	PUD NO 1 OF SKAMANIA CO	53057940500
31	WP0AH2A70J	Skagit	Anacortes	WA	98221	2018	PORSCHE	PANAMERA	Plug-in Hybrid Electric Vehicle (PHEV)	Not eligible due to low battery range	14	184400	40	214906548	POINT (-122.61214 48.51748)	ORCAS POWER & LIGHT COOP	53057940201
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The data in our set comes from registered electric vehicles in the State of Washington. We used public records to collect detailed information on each vehicle, such as Vehicle Identification Number, County, City, State, Postal Code, Model Year, Make, Model, and the Type of Electric Vehicle, either fully electric or hybrid. The data also includes whether each vehicle qualifies for clean fuel benefits, its Electric Range, suggested Retail Price, Legislative District, a unique Vehicle ID, Location, the Electric Utility serving it, and the Census Tract from 2020. We focused on collecting data that was readily available to ensure accuracy and to reduce the need for additional data generation. This information helps in understanding the distribution and preferences for electric vehicles across different regions of the state.

Views and Queries

View Name	JOIN (X4)	FILTER (X3)	AGGREGATE (X2)	LINKING (X1)	SUBQUERY (X1)
census_tract_info	X	X	X		
electric_vehicle_info	X			X	
vehicle_utility_location	X			X	

average_electric_range_per_model		X	X		X
legislative_location	X	X			

The following list describes what each query we wrote for our database displays:

Query 1: census_tract_info

Creates a view that focuses on geographical and locational data with aggregation incorporated into it. It starts by setting electric_vehicle as the active database and drops the census_tract_view if it already exists. The view is then recreated to include information from the census_tract_info table and location tables (county, city, state, and postal codes). Data is linked through an inner join on the census_tract_id, so the view only contains entries with matching records in both tables. It also counts the number of locations in each census tract and groups them together.

Query 2: electric_vehicle_info

Creates a view that displays the car, electric range, and base MSRP of electric vehicles.

Query 3: vehicle_utility_location

Creates a view that displays the location and utilities of electric vehicles based on their types.

Query 4: average_electric_range_per_model

A view that displays the average electric range of electric vehicle models from 2018 to 2022. It calculates the average range per model and model year, only including those with an average range greater than 22 miles, and orders the results by model year in descending order.

Query 5: legislative_location

A view named legislative_location that selects columns from the legislative_district_info and location tables. It provides detailed information about both such as location_id, district_id, etc. It filters results to only include data from the state of Washington "WA".

Changes From Original Design

In our initial project design, we proposed a set of entities that included attributes not present in our dataset, such as vehicle_id, veh_loc, elec_cap, veh_fin, spec_loc, elec_comp, and veh_specs. Upon reflection and consultation with our TA and mentor, we recognized that these entities were misaligned with the actual data available to us. The feedback prompted us to refine our approach, leading to the adoption of new entities like Vehicle, Location, Utility, Legislative District, and Census Tract. This change ensured that our database structure was more coherent and relevant, allowing for better organization and accessibility of data. We also designated the DOL ID as the primary key for the Vehicle entity to prevent duplication issues and reallocated attributes, such as moving 'Electric Range' back to the Vehicle entity, to ensure all data points were correctly assigned. These adjustments have greatly enhanced the overall design and functionality of our database, making it more aligned with our project's goals.

Database Ethics Considerations

In our electric vehicle database, we included a wide range of EV types from various automotive companies to ensure a representation of diverse manufacturers. Different vehicle types and price points across companies were documented to capture how economic factors influence EV adoption rates. To make our database an inclusive resource, we categorized owners by the type of EV they use, be it hybrid or fully battery-powered, without discrimination based on income. This approach prioritizes accessibility, allowing anyone interested in EV data, whether for research or educational purposes, to easily obtain and understand this information. We remained committed to maintaining confidentiality and only using essential data, ensuring that our database is not just comprehensive but also respects privacy and promotes equity in access to information.

During the first phase of this project, we identified potential privacy concerns with the DOL vehicle ID attribute, which could be considered Personal Identifiable Information (PII). We then used this attribute as both a primary key and a foreign key in our normalization process. This number has no ties to a person's first and last name as far as our database is concerned and thus it cannot be used to commit identity theft, reducing the likelihood of privacy violations. Furthermore, we identified the Vehicle Identification Number (VIN) as an attribute that could raise concerns due to its ability to reveal records about the first name, last name, and the

ownership and history of the vehicle. These concerns were taken into account, and as a result, this attribute was omitted in our normalization process.

Lessons Learned

As we worked on this project, we were able to learn more about teamwork and the importance of communication in achieving a shared goal. With the first deliverables of the project, everything was smooth-sailing and we had no issues with the concepts and completion of our individual parts. However, at the point of creating a logical design, we had a few challenges with the ERD tables and diagrams. It took a lot of communication and patience to correct our errors and complete the part. We spent a lot of time talking through it and learning from our mentors, as well as learning from each other and going through the steps slowly in order to make sure that all the grounds were covered. After learning from our mentors and discussing as a group, we decided to tackle the ERD problem by setting up a zoom meeting in which the only group member with a suitable PC shared their screen and everyone else went through the creation with him. A lot of communication and patience was what helped us to overcome this obstacle as a group.

Potential Future Work

In envisioning the future potential work for the electric vehicle database tailored to only the state of Washington, there emerges an idea of potential avenues of exploration such as widening the scope to the whole United States organized by state. This will allow us to gain deeper insight on a larger scale of the database across the country.. Another potential opportunity is that the database could evolve to encompass comprehensive data on various facets of EV ownership and infrastructure within the state. This might include detailed information on charging station networks, real-time availability, and accessibility to aid users planning their journeys. Additionally, as electric vehicle technology continues to advance, the database could expand to include information on emerging trends and developments, such as advancements in battery technology, autopilot driving, and other performance components. By continuously expanding and enhancing the database with a wider scope of geographic location, technology advancements, and other components to aid the user, the electric vehicle database has potential to be a valuable resource for individuals.

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