

Realistic Alternatives: Substituting the worst train connections with electrified highways.

MADE Project | Lisa Rebecca Schmidt

Travellers Might Prefer Cars over Trains due to longer Travel times.

75%

Of trips are faster by car.

30 Minutes

Average additional travel time by train.



Main Question.

Which routes between German cities are the slowest by train (vs. car)?

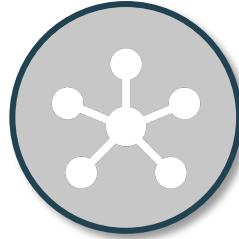


Train tracks are costly to modernize.

Which routes should be electrified for a "quick win" in climate action? (vs. new train tracks)



Three Data Sources Combined answer the Main Question.

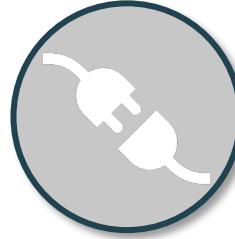


Connections

Statistic of travel times between the 100 largest cities in Germany.

Mobilithek

40k Measurements

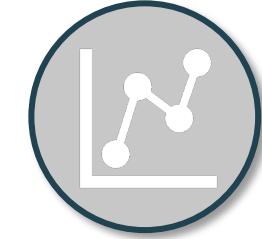


Chargers

Location of all registered publicly accessible charging points.

Bundesnetzagentur

54k Charger Locations



Development

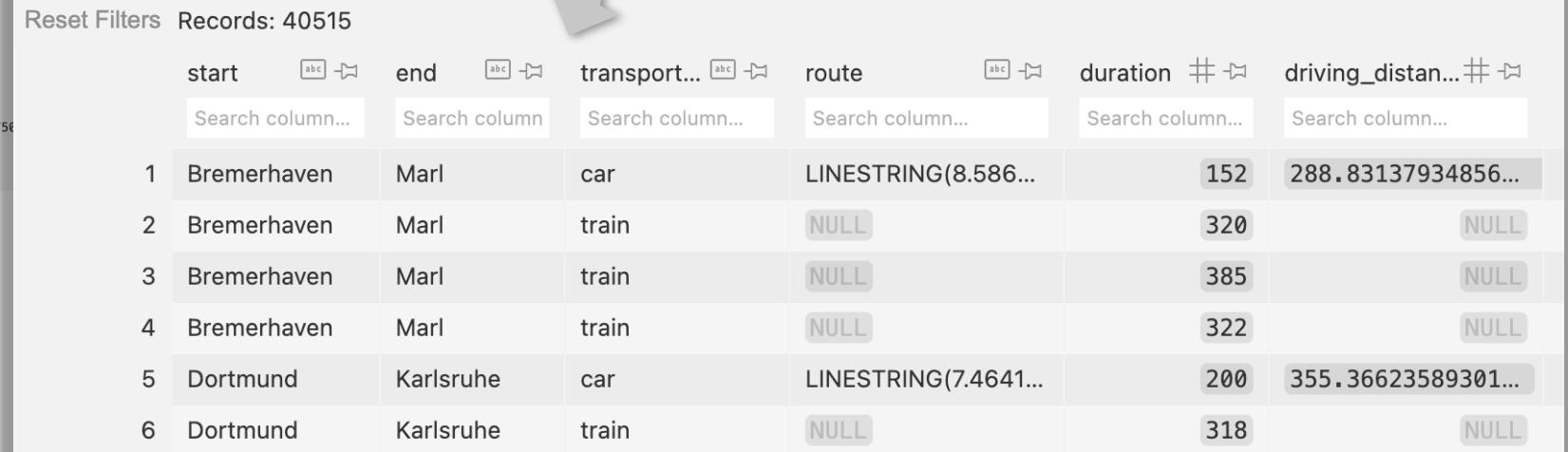
Evolution of the charging infrastructure by district.

Bundesnetzagentur

7 years of Statistics

Transforming the “Connections” Dataset.

```
data > moin-2022-05-02.1-20220502.131229-1.ttl
1 @prefix geo: <http://www.opengis.net/ont/geosparql#> .
2 @prefix moin: <http://moin-project.org/data/> .
3 @prefix moino: <http://moin-project.org/ontology/> .
4 @prefix owl: <http://www.w3.org/2002/07/owl#> .
5 @prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
6 @prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
7 @prefix schema: <http://schema.org/> .
8 @prefix wd: <http://www.wikidata.org/entity/> .
9 @prefix wdt: <http://www.wikidata.org/prop/direct/> .
10 @prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
11
12 << moin:Bremerhaven moino:connectedTo moin:Marl >>
13   moino:hasTrip [ moino:duration "PT32M"^^xsd:duration ;
14     moino:endTime "15:50:00"^^xsd:time ;
15     moino:startTime "10:28:00"^^xsd:time ;
16     moino:transportType moino:train
17   ] ;
18   moino:hasTrip [ moino:duration "PT385M"^^xsd:duration ;
19     moino:endTime "17:07:00"^^xsd:time ;
20     moino:startTime "10:42:00"^^xsd:time ;
21     moino:transportType moino:train
22   ] ;
23   moino:hasTrip [ moino:duration "PT320M"^^xsd:duration ;
24     moino:endTime "16:02:00"^^xsd:time ;
25     moino:startTime "10:42:00"^^xsd:time ;
26     moino:transportType moino:train
27   ] ;
28   moino:hasTrip [ moino:drivingDistance 288831.37934856815e0 ;
29     moino:duration "PT9134.0S"^^xsd:duration ;
30     moino:route "LINESTRING(8.586580000000001 53.551750
31     moino:transportType moino:car
32   ] .
```



The diagram illustrates the transformation process. On the left, a screenshot of a triple editor shows a portion of the 'moin-2022-05-02.1-20220502.131229-1.ttl' dataset. A large grey arrow points from this dataset towards a table on the right. The table has a header row with columns: start, end, transport..., route, duration, and driving_distan... (partially visible). Below the header are six data rows. Row 1: start=Bremerhaven, end=Marl, transportType=car, route=LINESTRING(8.586..., duration=152, driving_distan...=288.83137934856...). Row 2: start=Bremerhaven, end=Marl, transportType=train, route=NULL, duration=320, driving_distan...=NULL. Row 3: start=Bremerhaven, end=Marl, transportType=train, route=NULL, duration=385, driving_distan...=NULL. Row 4: start=Bremerhaven, end=Marl, transportType=train, route=NULL, duration=322, driving_distan...=NULL. Row 5: start=Dortmund, end=Karlsruhe, transportType=car, route=LINESTRING(7.4641..., duration=200, driving_distan...=355.36623589301...). Row 6: start=Dortmund, end=Karlsruhe, transportType=train, route=NULL, duration=318, driving_distan...=NULL.

Reset Filters Records: 40515						
	start	end	transport...	route	duration	driving_distan...
1	Bremerhaven	Marl	car	LINESTRING(8.586...	152	288.83137934856...
2	Bremerhaven	Marl	train	NULL	320	NULL
3	Bremerhaven	Marl	train	NULL	385	NULL
4	Bremerhaven	Marl	train	NULL	322	NULL
5	Dortmund	Karlsruhe	car	LINESTRING(7.4641...	200	355.36623589301...
6	Dortmund	Karlsruhe	train	NULL	318	NULL

- Triple-Serialized Graph is traversed and saved into table.
- Graph nodes are renamed to their city name.

Transforming the “Chargers” Dataset.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	Ladesäulenregister Bundesnetzagentur																			
2																				
3	Hinweis:																			
4	Die Liste beinhaltet die Ladeeinrichtungen aller Betreiberinnen und Betreiber, die das Anzeigeverfahren der Bundesnetzagentur vollständig abgeschlossen und einer Veröffentlichung im Internet zugestimmt haben. Die Zahl der öffentlich zugänglichen Ladeeinrichtungen in Deutschland ist daher größer als hier dargestellt.																			
5																				
6																				
7																				
8	Stand: 01.08.2023																			
9																				
10	Allgemeine Informationen																			
11	Betreiber	Strafe	Hausnummer	Adresszusatz	Postleitzahl	Ort	Bundesland	Kreis/kreisfrei	Breitengrad	Längengrad	Inbetriebnahme	Nennleistung	Art d	1. Ladepunkt	2. Ladepunkt					
12	Albwerk Gm	Ennabeurer V	0		72535	Heroldstatt	Baden-W.,rt Landkreis Alt	48,442398	9,659075	11.01.20	22 No	2 AC Steckdose	22							
13	smopi	Albstraße	14		72535	Heroldstatt	Baden-W.,rt Landkreis Alt	48,449353	9,672201	23.11.22	22 No	4 AC Steckdose	22							
14	Albwerk Gm	Parkplatz Cai	0		72589	Westerheim	Baden-W.,rt Landkreis Alt	48,5105	9,609	07.01.19	22 No	2 AC Steckdose	22							
15	EnBW mobil	Hauptstraße 91c			73340	Amstetten	Baden-W.,rt Landkreis Alt	48,5785342	9,8748399	19.03.19	98 S	2 AC Kupplung	43							
16	SWU Energie	Steingasse	6		88481	Balzheim	Baden-W.,rt Landkreis Alt	48,179959	10,076977	01.05.22	22 Normalladear	1 AC Steckdose	22							
17	LAN1 Hotspot Magirusstraf	16			89129	Langenau	Baden-W.,rt Landkreis Alt	48,500943	10,082036	13.09.23	33 Normalladear	3 AC Steckdose	11							
18	LAN1 Hotspot Magirusstraf	16			89129	Langenau	Baden-W.,rt Landkreis Alt	48,500943	10,082036	13.09.23	33 Normalladear	3 AC Steckdose	11							
19	Physiotherap Lange Strass	15			89129	Langenau	Baden-W.,rt Landkreis Alt	48,5010993	10,1221682	06.10.16	11 Normalladear	2 AC Steckdose	11							
20	Solarcollect	Eichlesstrass	18		89129	Langenau	Baden-W.,rt Landkreis Alt	48,505686	10,138781											
21	EnBW mobil	Karlstr.	45		89129	Langenau	Baden-W.,rt Landkreis Alt	48,505686	10,138781											
22	EnBW mobil	Flurst,ck	313		89129	Langenau/Sé	Baden-W.,rt Landkreis Alt	48,495353	10,076977											
23	EnBW mobil	Flurst,ck	313		89129	Langenau/Sé	Baden-W.,rt Landkreis Alt	48,495353	10,076977											
24	EnBW mobil	Flurst,ck	313		89129	Langenau/Sé	Baden-W.,rt Landkreis Alt	48,495353	10,076977											
25	EnBW mobil	Flurst,ck	313		89129	Langenau/Sé	Baden-W.,rt Landkreis Alt	48,495353	10,076977											
26	EnBW mobil	Parkplatz Bu	0		89129	Langenau	Baden-W.,rt Landkreis Alt	48,505686	10,138781											
27	EnBW mobil	Benzstraße	3		89129	Langenau	Baden-W.,rt Landkreis Alt	48,505686	10,138781											
28	EnBW ODR + Hindenburgs	3 Volksbank Al			89129	Langenau	Baden-W.,rt Landkreis Alt	48,495353	10,076977											
29	SWU Energie	Hausener Str	13		89129	Setzingen	Baden-W.,rt Landkreis Alt	48,538896	10,129616											
30	SWU Energie	Schulstraße	8		89129	Nerensteller	Baden-W.,rt Landkreis Alt	48,538896	10,129616											
31	SWU Energie	Keplerstraße	16		89129	Langenau	Baden-W.,rt Landkreis Alt	48,538896	10,129616											
32	SWU Energie	Sonnenstraße	4		89129	Langenau	Baden-W.,rt Landkreis Alt	48,538896	10,129616											
33	SWU Energie	Beethovenstr	40		89129	Langenau	Baden-W.,rt Landkreis Alt	48,538896	10,129616											
34	SWU Energie	Kuffenstraße	4		89129	Langenau	Baden-W.,rt Landkreis Alt	48,538896	10,129616											
35	SWU Energie	Ostersteller	14		89129	Langenau	Baden-W.,rt Landkreis Alt	48,538896	10,129616											

Records: 54223

operator	city	state	district	latitude	longitude
Albwerk GmbH & C...	Heroldstatt	Baden-Württemberg	Landkreis Alb-Dona...	48.442398	9.659075
smopi	Heroldstatt	Baden-Württemberg	Landkreis Alb-Dona...	48.449353	9.672201
Albwerk GmbH & C...	Westerheim	Baden-Württemberg	Landkreis Alb-Dona...	48.5105	9.609
EnBW mobility+ AG ...	Amstetten	Baden-Württemberg	Landkreis Alb-Dona...	48.5785342	9.8748399
SWU Energie GmbH	Balzheim	Baden-Württemberg	Landkreis Alb-Dona...	48.179959	10.076977
Physiotherapie im S...	Langenau	Baden-Württemberg	Landkreis Alb-Dona...	48.5010993	10.1221682
Solarcollect	Langenau	Baden-Württemberg	Landkreis Alb-Dona...	48.505686	10.138781
SWU Energie GmbH	Setzingen	Baden-Württemberg	Landkreis Alb-Dona...	48.538896	10.129616

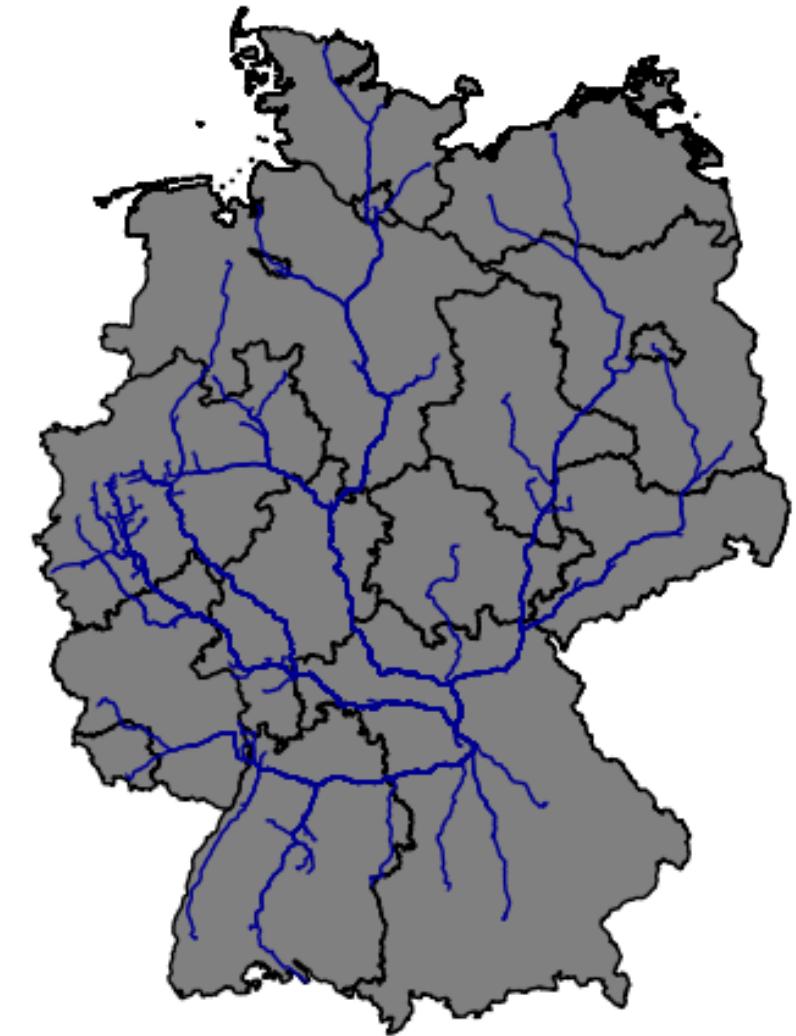
- Drop irrelevant rows.
- Transform geolocations to floats.
- Clean city/district names.

Transforming the “Development” Dataset.

- Select relevant table from sheet.
 - Save only relevant columns (yearly).

Erlangen is Well-Connected by Trains to Large Cities in Eastern Germany.

Destination	Distance	Absolute longer travel time [min]	Relative increase in travel time [%]
Berlin	501km	-73	-27,76 %
...
Trier	445km	136	+57,38 %



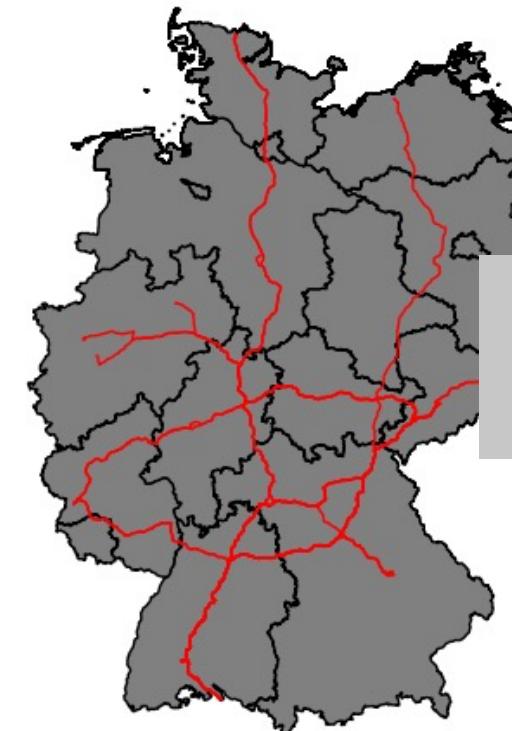
Which routes between German cities are the slowest by car?



"Worst Offender"
Duisburg-Moers
+245%

Highest relative deviation

Short-distance Routes in North-Rhine-Westfalia are better taken by car.



"Worst Offender"
Konstanz-Chemnitz
+225min

Highest absolute deviation

Routes Crossing whole Germany
Produce Longest Delays.

Main Question.

Which routes between German cities are the slowest by train (vs. car)?

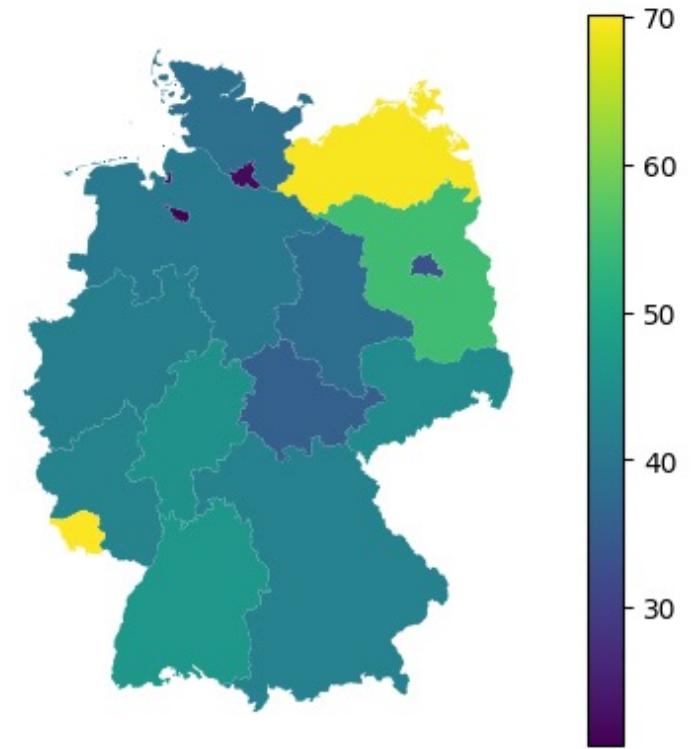
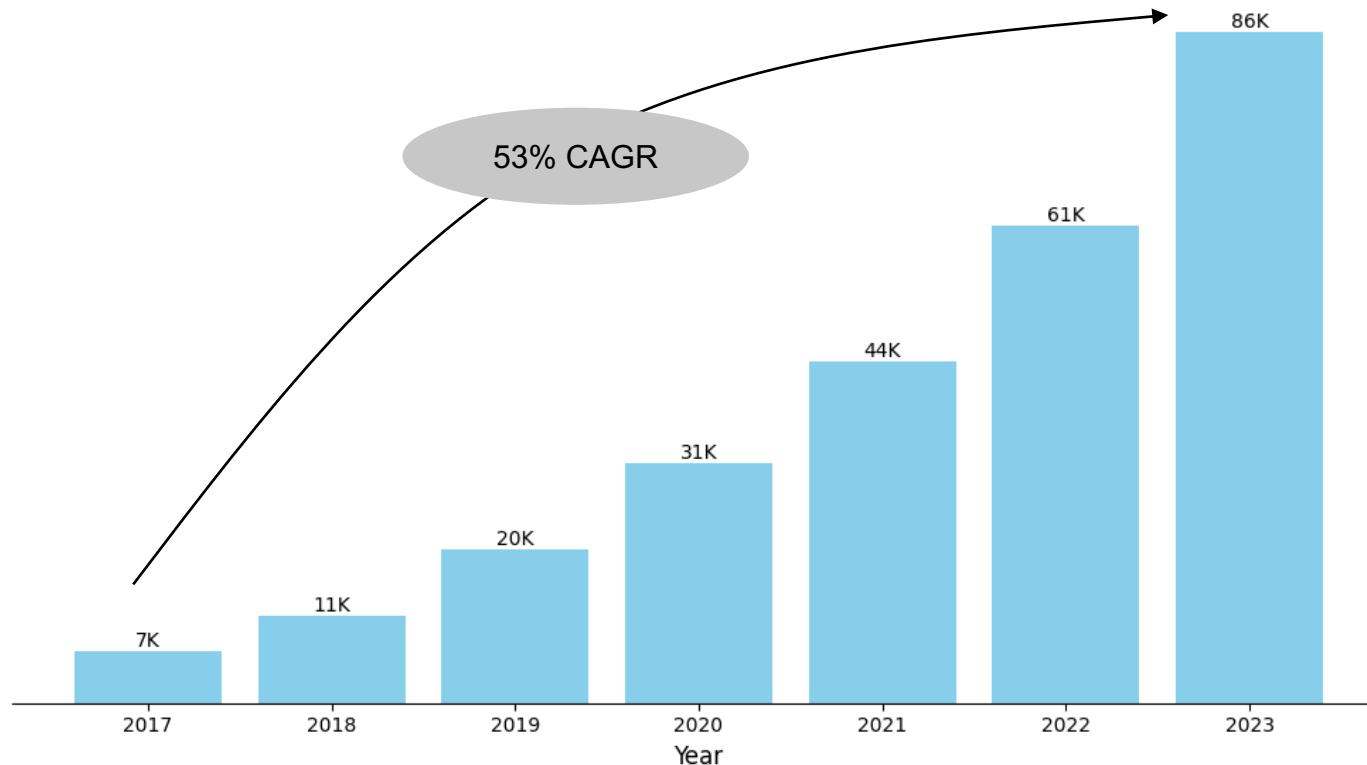


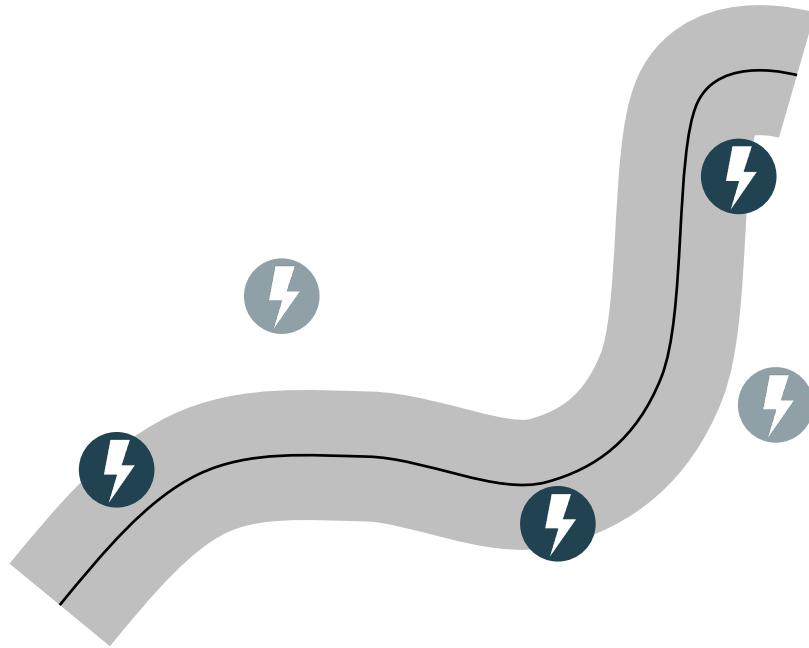
Train tracks are costly to modernize.

Which routes should be electrified for a "quick win" in climate action? (vs. new train tracks)



Mecklenburg and Saarland show an above-average Growth Rate of over 70% CAGR.

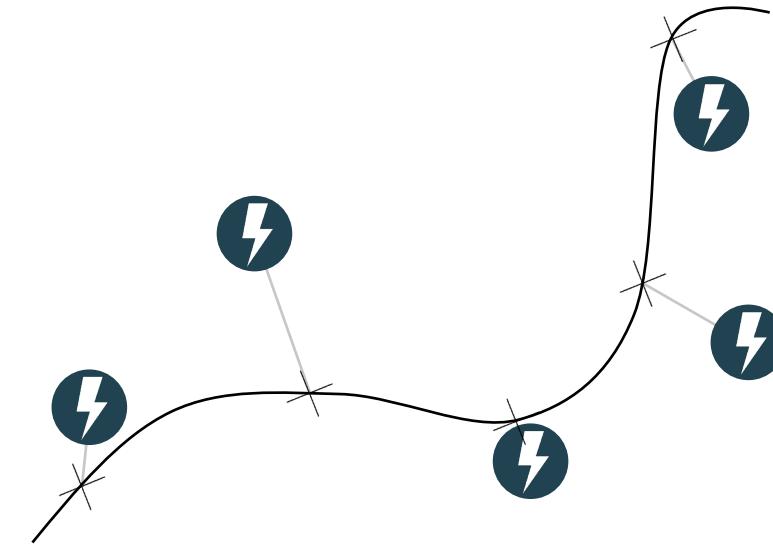




Charger Density

chargers on the route / length of route

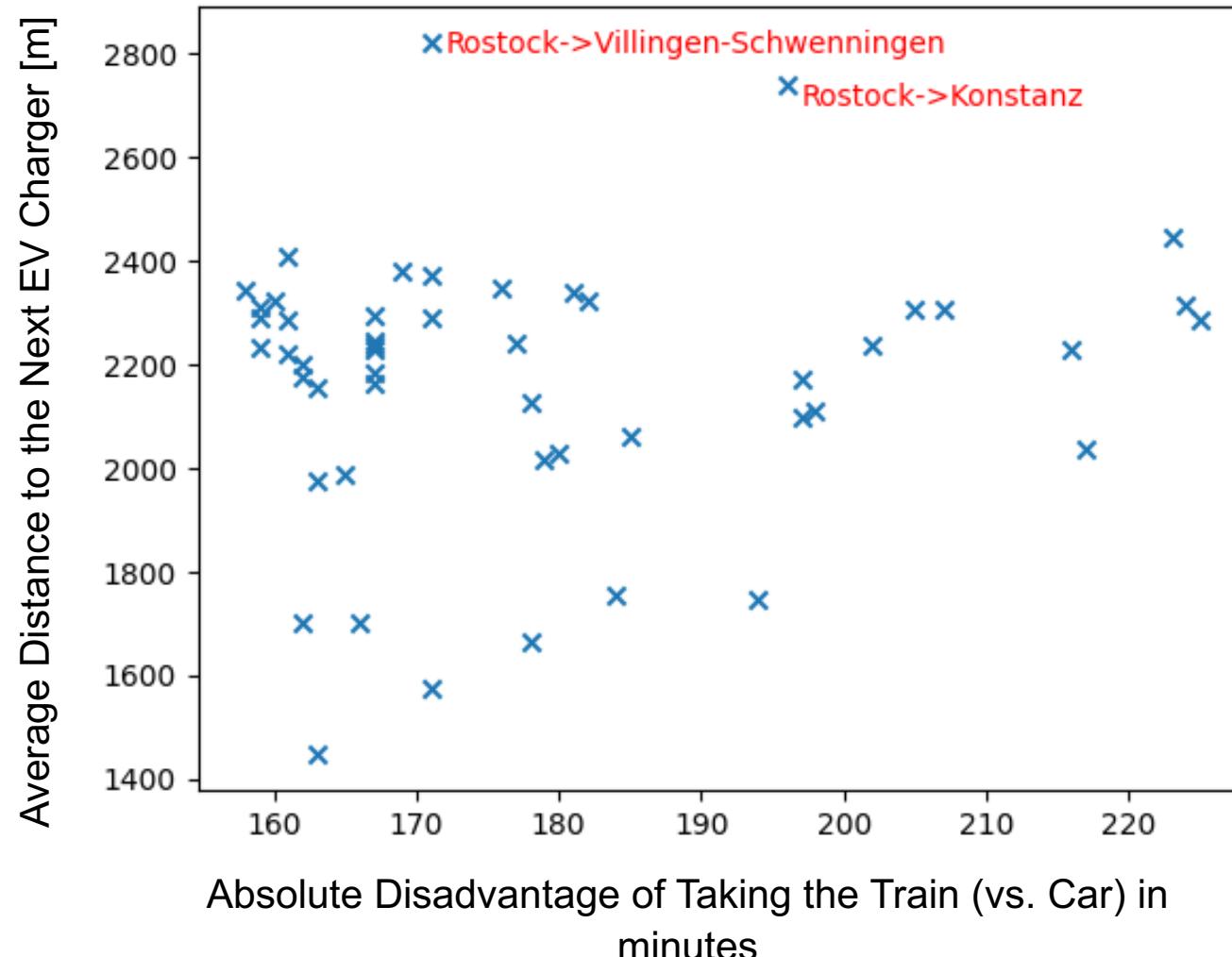
A charger is “on the route” if its within 500m of the route.



Avg. Distance to Next Charger

Sampling points along the route, then noting distance to the nearest charger.

Routes from Rostock to Baden-Württemberg most strongly require more EV chargers.



Main Question.

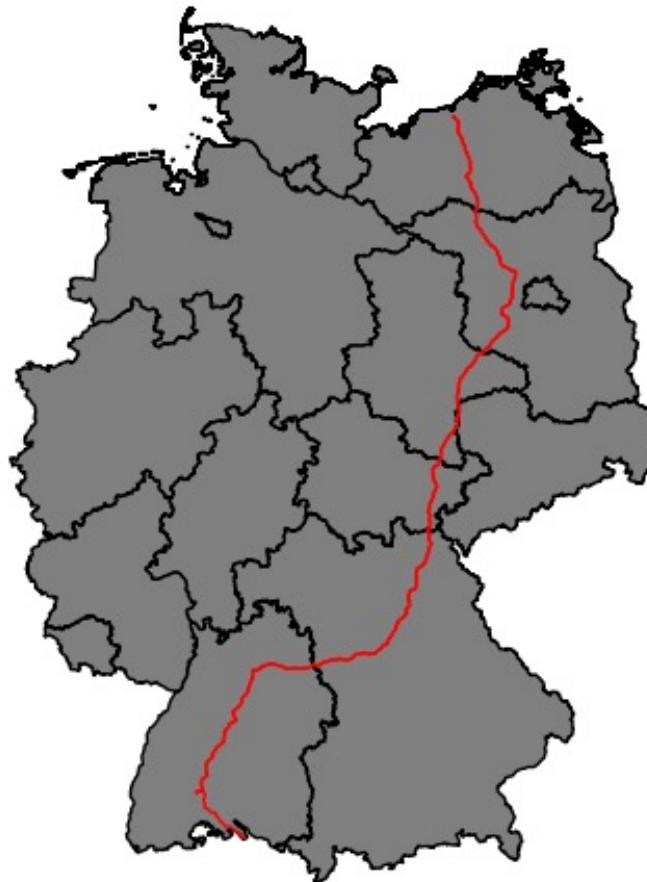
Which routes between German cities are the slowest by train (vs. car)?



Train tracks are costly to modernize.

Which routes should be electrified for a "quick win" in climate action? (vs. new train tracks)





The project recommends adding charging stations to the routes **Rostock/Villingen-Schwenningen** and **Rostock/Konstanz**.

This is less costly and time-consuming than modernising the connecting railways and still promises an advantage in emissions.

- Identifying which districts in Germany are not electrified well to decide on financial aid from federal government.
- Looking into the number of passengers along each route to also influence the decision.
- ... Let me know your ideas! ☺



Thank you for Listening.

Repository:

<https://github.com/LisaRebecca/data-engineering-showcase>