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**Working Paper**

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## Working Paper No. 705

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### Spatial scenarios of potential electric vehicle adopters in Ireland

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**Abstract:** Transition to electric vehicles is among one public policy to reduce carbon emissions from the transport sector in Ireland. While EV adoption rates are increasing there is broad scepticism about achieving ambitious national policy targets. Using microdata on commuting behaviour and standardised assumptions based on existing literature, we identify candidates that could comfortably satisfy weekly driving needs using an EV without the need to alter behaviour for EV charging purposes. High density areas of potential candidates for transition to EVs are identified, particularly in specific urban areas of Cork and Dublin cities. We also find between 2 to 37% reduction in emissions from car owners based on the different set of assumptions we employ. While the per unit emission reduction in rural areas is higher, the aggregate emission reduction that can be achieved is higher in urban areas because of the higher density of candidates for transition in such areas. The charging infrastructure in these urban areas is already well-developed and marketing campaigns targeting groups such as environmentally conscious younger individuals, who are not often characterised as ‘early adopters’ in the literature, may pay off in such areas. Public campaigns with a local character in the areas with clusters of the candidates can be more effective in improving the adoption rates.

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# 1 INTRODUCTION

In Ireland, transportation is the largest energy-consuming sector with a 42% share of final energy consumption and it accounts for 41% of energy related emissions. Passenger transportation is the largest polluter in this sector (SEAI, 2020). In Ireland and in other countries around the world, electrification of the sector is key in the policy agenda to transit towards a more sustainable economy. However, the uptake of this technology has been very slow. Previous literature identifies various individual, technological and infrastructure characteristics which drives the potential adoption of electric vehicles (Zhuge & Shao, 2019; Vassileva & Campillo, 2017; Plötz et al., 2014; Westin et al., 2018). Mukherjee & Ryan (2020) note that the early adopter population in Ireland shows similar characteristics to the ones found elsewhere. Range anxiety and lack of awareness about existing technology and infrastructure can reduce adoption rates of EV technology (Thøgersen & Ebsen, 2019). In this study, we examine the spatial distribution of candidates for a switch to Plug-in Electric Vehicles (PEVs), more specifically Battery Electric Vehicles (BEVs), in the Republic of Ireland using Census data<sup>1</sup>. Based on actual commuting activity data and standardised assumptions on EV distance capability, we define the candidates as those vehicle owners<sup>2</sup> with at least two vehicles and whose existing weekly commuting distances are comfortably within the range capability of a standard BEV battery charge. We assume that these candidates could switch one of their cars to a BEV without adding much hassle/delay to their regular commuting patterns/times and without encountering commonly cited problems of limited range. Further, we expand our analysis by employing the socio-demographic factors which drives the adoption of EVs as identified in the literature.

Our primary objective is to study the distribution of candidates for switching one of their vehicles to an EV and the potential environmental saving from switching. We also extend this analysis to include estimation of gains through emission reduction from that switch and an examination of charging infrastructure network in close proximity to such clusters. Based on the distribution of candidates for switching their second vehicle to an EV as per our various scenarios, we estimate the potential aggregate and average emission savings from each scenario. Globisch et al. (2019) find that proximity to charging infrastructure can improve adoption of EVs among non-traditional adopters. With this aim, we map clusters with close proximity to high density of existing charging infrastructure and in turn identify areas where possible charging network expansion might improve adoption based on the clustering of potential buyers. Understanding the spatial distribution of candidates for switching to BEVs will help in developing local EV targets and thereby help in designing local marketing campaigns associated with specific areas which can localise national promotional campaigns.

Zhuge & Shao (2019) in their study in Beijing, China identify 6 factors which influence the uptake of electric vehicles. They rank the factors according to their relative importance; vehicle price is the most

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<sup>1</sup> BEVs are EVs with zero tail pipe emissions unlike hybrid electric vehicles. Furthermore, in this study we are concerned with potential adopters with range anxiety. Range anxiety is not a concern for hybrid vehicle adopters. Hence, in this study we are focusing on the adoption of BEVs.

<sup>2</sup> It should be noted that the unit of analysis in this study is a car owner whose mode of commute is driving their car. The vehicle/s owned can be used by the 'vehicle owner' or 'candidate' for their own transport needs and/or their household's.

67 important determinant followed by vehicle usage, social network and environmental awareness. The  
68 socio-demographic attributes influencing uptake include age, gender, education level, job type, income  
69 and number of vehicles. In a study conducted in Denmark, [Thøgersen & Ebsen \(2019\)](#) find that potential  
70 adopters are often unaware of or are unconvinced about the technological improvements when it comes to  
71 EV technology and availability of charging infrastructure. [Guerra & Daziano \(2020\)](#) note, in their study  
72 of potential adopters from Philadelphia, USA, that commuting distances, charging point availability and  
73 affordability can be critical in the decision to buy a PEV. Such preferences are also influenced by the resi-  
74 dential area and accommodations available, such as parking spots with or without charging infrastructure  
75 in urban areas, for each individual. Hence, they argue future studies should incorporate commuting in-  
76 formation and proximity to charging infrastructure to correctly identify a household's potential to buy a  
77 PEV. Hence in our study we estimate commuting distances using location information from census of Ire-  
78 land. After considering the range of EVs in Irish market, we assume that a vehicle owner with a smaller  
79 commute to work can charge the vehicle once a week and complete all of their travel without worrying  
80 about recharging. Hence if their estimated weekly commute distance is below the range of common EVs  
81 in the market, we consider them as a candidate for switching their second vehicle based on commuting  
82 patterns. By using weekly distance travelled, we are introducing very restrictive distance-based filters in  
83 identifying potential buyers thus our analysis is very conservative.

84 As to the socioeconomic drivers of EV adoption, [Haustein & Jensen \(2018\)](#) in their study in Denmark  
85 and Sweden find that BEV owners are typically male, highly educated, have higher incomes and have of-  
86 ten more than one car in the household compared to conventional car users. [Vassileva & Campillo \(2017\)](#),  
87 in their study in Sweden, find that early EV adopters typically charge their car at home at night. [Plötz et  
88 al. \(2014\)](#) find that men who are middle aged and working in technical jobs are some of the early adopters  
89 of EV technology in Germany. [Westin et al. \(2018\)](#) note that while socio-demographic variables like gen-  
90 der, age, income, employment, and education level can be associated with early adopter behaviour, when  
91 controlled for other factors these associations may disappear. [Mukherjee & Ryan \(2020\)](#) find that EV  
92 adopters in Ireland are typically aggregated around the urban areas and have socio-demographic charac-  
93 teristics similar to the early adopters elsewhere. Their study employs micro-data of EV adopters in Ireland  
94 to study the spatial distribution of existing EV owners. Based on these studies, we build the profile of  
95 candidates for switching to a BEV. Since our study involves only vehicle owners who own more than  
96 one car, we do not take gender as a factor in our profile as we assume that the EV purchase decision is a  
97 joint decision in a household. Hence, in our more restrictive scenario which considers a socio-economic  
98 profile of potential buyers in addition to the distance-based criteria, a candidate for switching their second  
99 vehicle is a middle aged, highly educated vehicle owner working in higher income professions, who owns  
100 their home and more than one car.

101 There are studies which previously tried to understand the distribution of potential adopters of EV  
102 technology using different data sources ([Namdeo et al., 2014](#); [Saarenpää et al., 2016](#); [McCoy & Lyons,  
103 2014](#)). [Saarenpää et al. \(2016\)](#) identify areas favourable for PEV adoption in Finland by mining public  
104 data. [McCoy & Lyons \(2014\)](#) employ agent-based modelling to study the diffusion of EV technology

105 in Ireland using survey data. This study emphasises that targeting ‘early adopters’ for messaging may  
106 not result in faster adoption unless detailed network topology is well understood. [Namdeo et al. \(2014\)](#)  
107 identify hot spots for expanding the charging infrastructure in urban areas in Northeast England through  
108 spatial analysis of the socio-economic characteristics and commuter information of urban residents. Our  
109 study adds to this literature by attempting to identify spatial clusters where large number of candidates  
110 for switching one of their vehicles to an EV can be found mainly based on commuting distances. Extend  
111 of emission reduction is central in the debates surrounding EV adoption, hence we include the estimation  
112 of emission reductions which can be achieved by each scenario we design as well.

113 When it comes to the role played by charging networks in the adoption of EVs, [Globisch et al.](#)  
114 [\(2019\)](#) note that proximity to EVSE (Electric Vehicle Supply Equipment’s) can be critical to a subset of  
115 non-traditional adopters. These groups do not belong to the profile of middle aged, male, high income  
116 earning early adopters, but are technophilic, environmentally aware younger individuals, mainly women.  
117 This sub-group may be residing in apartments or do not own their residences. Hence, they argue that  
118 expanding charging infrastructure especially fast charging points may help to speed up the adoption of  
119 EVs among non-traditional early adopters. [Funke et al. \(2019\)](#) note that in countries like the Netherlands  
120 where the proportion of detached houses is lower, availability of fast charging networks and slow charg-  
121 ing networks in public parking spots has reduced the need for home charging infrastructure. In other  
122 areas like the US, charging networks are important in metropolitan areas compared to areas with more  
123 detached homes ([Guerra & Daziano, 2020](#)). Improved quantity and quality of charging infrastructure  
124 along with marketing campaigns which reduce misconceptions of EV technology and existing infrastruc-  
125 ture can improve adoption in Denmark as per the study by [Thøgersen & Ebsen \(2019\)](#). A majority of  
126 Irish households live in detached and semi-detached homes according to the latest census. However, ur-  
127 ban areas like Dublin city have a share of 35% of households living in apartments ([CSO, Ireland, 2016](#)).  
128 Hence in this study we explore the proximity of current charging infrastructure in Ireland to hotspots  
129 of candidates for switch to a BEV and study the density of charging points near clusters. Clusters near  
130 existing charging infrastructure can be foci for marketing campaigns which target non-traditional early  
131 adopters. Expansion of charging networks in existing low-density areas might accelerate the adoption of  
132 EVs among population who do not fit the ‘early adopter’ profile.

133 The current Irish EV adoption statistics raise significant scepticism about the feasibility of achieving  
134 ambitious targets set by Irish government ([McAleer, 2019, June 18](#))<sup>3</sup>. The Irish government plans to  
135 increase the number of EVs in Ireland to 1 million by 2030 as per the Climate Action Plan ([Govt. of](#)  
136 [Ireland, 2019](#)). Early reports in 2021 indicate that the popularity of EVs in the Irish market is showing  
137 an upward trend ([O’Sullivan, 2021, February 23](#)). Our study can identify pockets of geographical areas  
138 where a high density of candidates for switching their second vehicle to an EV can be found and targeted  
139 for a quick transition to electric vehicles. According to the National Transport Survey of Ireland ([CSO,](#)  
140 [Ireland, 2019](#)), purchase price/ affordability is the main factor influencing the decision to purchase an EV  
141 for Irish citizens. The Irish government has already introduced purchase grants, Vehicle Registration Tax

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<sup>3</sup> As of 2020, there are 8,473 BEVs registered in Ireland. The current EV adoption statistics for Ireland is shown in table [A.1](#).

142 (VRT) relief, toll incentives, home charger installation grants and reduced motor tax rates to encourage  
143 adoption of EVs (Kevany, 2019). Availability of more charging points away from home and availability  
144 of overnight charging at low cost were also factors influencing decision to adopt EV technology as per  
145 CSO, Ireland (2019).

146 While many papers consider the diffusion pathway of EVs and likely early adopters, the current  
147 approach differs in two ways. First, we begin from perspective of households' transport needs and the  
148 technical capacity of current technology EVs to deliver such service rather than simply focusing on socio-  
149 demographic traits and likelihood of EV adoption. Second, we design the analysis to preclude situations  
150 where EV range anxiety may be a concern. Hence, within existing commuting/driving requirements and  
151 using EV technology currently available on the Irish market, we estimate the technical potential for EVs  
152 to comfortably satisfy existing transport needs. This provides an estimate of where existing fossil fuel  
153 vehicles can be substituted with EVs without compromise or accommodation in travel patterns. As this  
154 estimate ignores factors such as budget constraints or behaviour decisions, following the literature on EV  
155 adoption, we drill down to the sub-sample of candidates that are more likely to be early EV adopter based  
156 on socio-economic characteristics. This is a more conservative estimate of where existing fossil fuel  
157 vehicles can be substituted with EVs without compromise or accommodation in travel patterns. Emission  
158 reduction achieved by potential adoption can play an important role in marketing campaigns targeting the  
159 more environmentally conscious subgroups. Hence our study includes estimates of emission reductions  
160 in the scenarios developed. Lastly, charging networks can be critical in the adoption decisions of non-  
161 traditional adopters and hence, we study how the clusters of candidates for switching their existing vehicle  
162 intersect with good coverage of existing charging infrastructure.

## 163 **2 Data and methodology**

164 The analysis in this study utilises the Place of Work, School or College (POWSCAR) data from the Census  
165 of population of Ireland 2016 dataset (CSO, Ireland, 2018). The unit of analysis in this study is a candidate  
166 for switching their second vehicle to a BEV, whom we assume to be a vehicle owner who commutes by car  
167 to work and belongs to a certain subsection of population as per the literature<sup>4</sup>. 39.3% of vehicle owners in  
168 the census owns at least one car and drives to work. We do not include car commuters who are passengers  
169 in our sample to avoid double counting. The main variables of interest in this study are geographical  
170 location of work and home, socio-economic characteristics and vehicle ownership data obtained from  
171 POWSCAR dataset along with location information of EV charging infrastructure in Ireland (descriptive  
172 statistics shown in table 1).

173 Data on commuting distance, car ownership and socio-demographic characteristics are employed to  
174 identify candidates where EVs can easily accommodate travel needs. For convenience we describe these

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<sup>4</sup> We assume that range anxiety is a major concern to a potential adopter who use their car for daily routine journeys compared to someone who uses their car for occasionally journeys. Our analysis provides a conservative estimate due to this restrictive assumption.

175 as candidates for switching to EVs. Based on these we develop 2 scenarios to identify candidates for  
176 switching to a BEV. The number of car commuters (and are also drivers) who belong to each scenario is  
177 aggregated to Electoral Division level to study their spatial distribution. Further we estimate emissions  
178 savings that can be achieved from switching to EVs based on each of our scenarios. In areas identified  
179 as having high EV switching potential, we utilise the information related to charging infrastructure to  
180 identify the areas with existing good coverage of charging points and where expansion is needed. The  
181 following subsections will explain the assumptions employed in our analysis along with the descriptive  
182 statistics of indicators we develop.

## 183 **2.1 Estimating weekly distance travelled**

184 The POWSCAR dataset includes location data of work and home at Small Area level<sup>5</sup> for each individual.  
185 From this information the distance between work and home is calculated. The Euclidean distance between  
186 the centroid of Small Area of work and Small Area of home in kilometres is considered as the distance  
187 to work. The Euclidean distance is the length of a line segment between two points in Euclidean space  
188 (Pebesma, 2018; Karney, 2013). The distance estimation in that case is not an accurate estimation when  
189 it comes to the commuting distance because it does not consider route variations, congestion, or other  
190 road delays (Sander et al., 2010). Hence, we double the Euclidean distance as commuting distance in our  
191 sensitivity analysis scenario. We assume that the real-life scenario will be somewhere closer to the main  
192 estimation method or between the main estimation method and sensitivity analysis scenario.

193 We employ weekly distance travelled instead of daily distance travelled in our analysis. We employ  
194 two methods for estimating total weekly distance travelled by the vehicle owner considered. We consider  
195 the first method as our main distance estimation method and the second one as our sensitivity analysis  
196 estimation method. We estimate work and non-work related travel separately to calculate the total dis-  
197 tance travelled in a week. The distance to work is calculated from the Euclidean distance estimation as  
198 explained earlier. To estimate non-work related travel, we consider that the average distance travelled by  
199 a private car annually in Ireland is 18,000 km for urban areas and 20,000 km for rural areas (CSO, Ireland,  
200 2021). Based on this we estimate that a private car in urban area travels approximately 350 Km per week  
201 and a private car in rural area travels around 385 km per week. CSO, Ireland (2021) estimates that only  
202 25% of journeys undertaken by private cars are work related in Ireland. Hence, we add 250 km to urban  
203 area weekly journeys and 285 to rural area weekly journeys as distances travelled for non-work related  
204 activities in a week<sup>6</sup>. When it comes to total commute to work, we estimate that a typical car commuter

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<sup>5</sup> They are the smallest administrative boundaries in Ireland.

<sup>6</sup> Some of the non-work related distances travelled may be pooled in the case of multi-car households with multiple car commuters. In this study we assume that all cars used for commute will travel the same non-work related distances. Hence our distance filter will be providing a more conservative estimate.

205 might travel 10 times per week to work. We use the following formula to calculate the distance travelled  
206 in a week as per the first method.

$$\text{Weekly distance travelled}_h = \text{Distance to work}_h * 10 + \text{Distance travelled for non-work related activity} \quad (1)$$

207 Further we employ a second method to estimate the weekly distance travelled based on different  
208 set of assumptions for checking the sensitivity of our assumptions. In this method, we assume that the  
209 Euclidean distance do not completely capture the distance to work and hence double the distance to work  
210 to account for traffic and route variations. Average distance to work in the data (as per this assumption)  
211 is 34 km. Hence in line with CSO, Ireland calculations of annual mileage of private cars, we add 60 km  
212 to distance travelled in a week to urban areas and 120 km to rural areas. To calculate weekly distance in  
213 this method, we use the following formula.

$$\text{Weekly distance travelled}_h = \text{Distance to work}_h * 20 + \text{Distance travelled for non-work related activity} \quad (2)$$

214 In our analysis, the first method, which applies a more conservative assumption on non-work related  
215 travel, is considered as the main method and the second method, which applies a more conservative  
216 assumption on work related travel, is employed for sensitivity analysis. We take into account the total  
217 distance travelled in a week by potential buyers and classify those distances as above or below the range  
218 of a typical BEV. The information on distance ranges that electric cars in the market can travel from a  
219 single charging session was gathered from various sources including the Sustainable Energy Authority  
220 of Ireland (SEAI, 2021). Based on this we calculate the quantiles of distance ranges an EV in market  
221 can travel from a single recharge. To determine the cut off range for filtering out possible candidates for  
222 switching their second vehicle based on weekly commuting distance, we chose the 25th percentile range  
223 as a lower limit and 75th percentile as the upper range limit reached by BEVs in Irish market. The 25th  
224 percentile is 310 km and 75th percentile is 436 km as per this calculation. Two of the most popular BEVs  
225 in Ireland are Hyundai Kona with a distance range of 449 km and Nissan Leaf with a range of 378 km.  
226 Hence our upper range distance calculation is closer to the range of common EVs in Irish market.

## 227 **2.2 Scenarios for identifying candidates for switching their second vehicle to a BEV**

228 Range anxiety is one of the main reasons for non-adoption of electric vehicles as per the literature  
229 (Thøgersen & Ebsen, 2019). If a potential adopter or their household can travel all of their journeys  
230 in a week as per above calculations in a single charging session of the EV, we assume that they can easily  
231 transition their second vehicle to an EV. It should be noted that the estimate here is highly conservative  
232 and most households travel far less distance in a week than we estimate. We devise two scenarios for  
233 identifying candidates for switching their second car to a BEV based on two different set of assumptions.



### 234 **2.2.1 Scenario 1: Commuters with two cars**

235 In the first scenario we employ data on weekly distance travelled and car ownership to study the distri-  
236 bution of candidates for switching their second vehicle (shown in table 2). For identifying the potential  
237 buyer population at an ED level, we add the number of car commuters (only drivers counted) in an ED  
238 who fulfils the distance criteria and owns two or more cars. Both high and low range mileage attained  
239 by the EV's in market are used for the analysis to understand how the hotspots will expand with the  
240 improvement of battery technology. As explained earlier we assume that candidates who own more than  
241 one car can convert one of their vehicles to a BEV without adding any inconvenience to their existing  
242 commuting patterns. About 72.4 % of car commuters who drive to work owns at least 2 cars in Ireland  
243 (see table 1). The POWSCAR data does not include information on the main purpose for which each car  
244 is used. In some cases, a second car may be used only for occasional journeys such as school runs. In  
245 such cases the second car can be transitioned to an EV without worrying about range. Hence the estimate  
246 provided in this paper may be a more conservative figure considering the distance based filters applied.

### 247 **2.2.2 Scenario 2: Commuters with two cars who belong to the socio-economic profile of EV pur-** 248 **chaser**

249 In the second scenario we also consider the socio-economic characteristics of the car driver based on  
250 literature related to EV adoption (shown in table 2). To avoid counting the same vehicles twice, we only  
251 include the individuals within the household who 'drive to work' in our analysis . The census data used  
252 for analysis provides information on commuting modes for each unit. The socio-economic characteristics  
253 employed in this study includes education, socio-economic group (SEG) which the vehicle owner belong  
254 to, home ownership status and age of candidates for switching to a BEV. As per the literature, early  
255 adopters of electric cars are highly educated higher income middle aged individuals. Hence in this study  
256 we identify such vehicle owners as candidates for switching their second vehicle in our dataset. Managers,  
257 employers, lower and higher professionals are coded as high-income individuals in this study <sup>7</sup>. Vehicle  
258 owners with a university degree are considered as highly educated for this study. The assigned age group  
259 of candidates for switching to a BEV is 35-54. As per literature homeowners of detached homes can  
260 install the required charging infrastructure without much hassle and hence home ownership is employed  
261 as a determinant of EV adoption in this study. We do not have data on the type of residence in our dataset.  
262 Descriptive statistics for categorical variables which are indicators of these socio-economic characteristics  
263 which make an individual a candidate for switching their second vehicle to an EV are given in table 1.  
264 If a vehicle owner owns 2 or more cars, travels within the battery capability of a typical EV on single  
265 recharge in a week, belongs to a higher SEG, have higher educational attainment, is middle aged and owns  
266 their home, we consider them as a candidate for switching their second vehicle to an EV. This method is  
267 much more restrictive than Scenario 1. We count the number of candidates at ED level. Similar to the  
268 first scenario we repeat the analysis by employing weekly distance calculation done via the sensitivity

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<sup>7</sup> We do not have access to the data on income of individuals.

269 analysis method as well and employ scenarios where the preferred EV is low and high range. We do not  
 270 report the results from sensitivity analysis since they are very close to the main method aggregates.

	Mean	SD
Distance to work (km)	17.7	26.5
Charging point count per ED	1.53	0.91
Charging points within 3 KM (per ED)	12.07	13.87
	Count	Percentage
Candidate SEG (ref. cat: Yes)	535,393	46.3
Candidate education (ref. cat: Yes)	656,500	56.8
Cars owned		
No car	2,990	0.003
1 car	315,641	0.27
More than 1 car	838,828	72.6
Candidate age group (ref. cat: 35-54)	648,527	56.1
Dwelling owned (ref. cat: Yes)	892,348	77.2

Note: Sample size is 1,154,469

**Table 1: Descriptive statistics**

Conditions applied		Scenario 1		Scenario 2	
		EV range		EV range	
		Low: 310 km	High: 436 km	Low: 310 km	High: 436 km
Distance related (sum less than EV range)	Weekly work commute Distance to work * 10	✓	✓	✓	✓
	Non-work related commute Urban: 250 km Rural: 285 km	✓	✓	✓	✓
		✓	✓	✓	✓
SEG based (belongs to)	Own 2 or more cars	✓	✓	✓	✓
	Candidate SEG			✓	✓
	Candidate education			✓	✓
	Candidate age group			✓	✓
	Dwelling owned			✓	✓

**Table 2: Summary of assumptions employed in the two scenarios of analysis**

### 271 **2.3 Emission reduction achieved from the scenarios**

272 The emission reductions from each scenario are calculated using estimates for recorded emissions per  
 273 km of travel from petrol and electric cars. Tailpipe emissions per km employed in this study is 130g for

274 conventional/petrol cars and 0 g for electric vehicles. <sup>8</sup> From the weekly commuting distance, the annual  
275 emissions estimate for each potential buyer is calculated by aggregating weekly emissions. The aggregate  
276 emissions are calculated by taking the sum of emissions from all potential buyers as per each scenario.  
277 The aggregate emission from each scenario is calculated by

$$\text{Annual aggregate emissions} = \sum_h^H (\text{Weekly commute distance}_h * 52 * \text{Emissions per km}) \quad (3)$$

278 where h goes from 1 to H, the total number of candidates in each scenario. Weekly commute distances  
279 calculated using main method and sensitivity analysis method are separately employed for estimation.

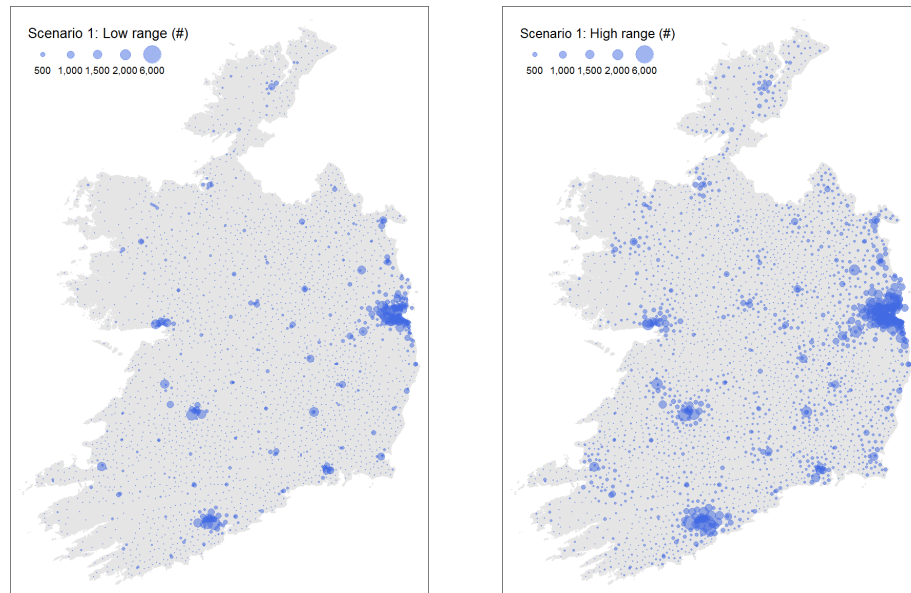
## 280 **2.4 Distribution of charging point density**

281 We obtain location data on EV charging points across the Ireland installed by the Electricity Supply Board  
282 of Ireland. It should be noted that private charging stations which accounts for a smaller proportion of  
283 charging points across Ireland are excluded from our analysis. We use geocoded location data on public  
284 charging points across Ireland to determine the candidate's proximity to public charging points (ESB,  
285 Ireland, 2021). Presence of public charging points or workplace charging infrastructure can be crucial in  
286 the decision to buy a BEV for a certain sub-section of population who may not own their homes or live in  
287 apartments (Globisch et al., 2019). About 34% of vehicle owners in the dataset works within 3 km of their  
288 home, hence we calculate the number of charging points within 3 km of ED centroid to study proximity  
289 of candidates to a charging point. We use the topological relations between spatial objects, in this case the  
290 number of charging points within 3 km radius of the ED centroid, to estimate the charging point density  
291 (see Rigaux et al. (2001); Pebesma (2018); Wickham et al. (2019)). We take snapshots of areas with high  
292 density of potential buyers to study how the existing charging networks span within such areas. Since  
293 all these areas are urban areas and hence may include large number of renters and individuals who live  
294 in apartments, we map the charging point density within 3 km of the home as well in these plots. These  
295 maps can highlight areas of high density of potential buyers with or without good charging infrastructure.  
296 This analysis will highlight hotspots with existing good charging infrastructure and those which needs  
297 more expansion. This can help to accelerate adoption among non-traditional early adopters as explained  
298 earlier.

	Scenario 1		Scenario 2	
	Low range	High range	Low range	High range
Count	194,422	481,077	34,670	94,386
Share (%)	16.8	41.6	3.0	8.1

Note: share out of 1,154,469 (Individuals who own at least 1 car and drive to work)

**Table 3: Aggregate count of potential buyers**



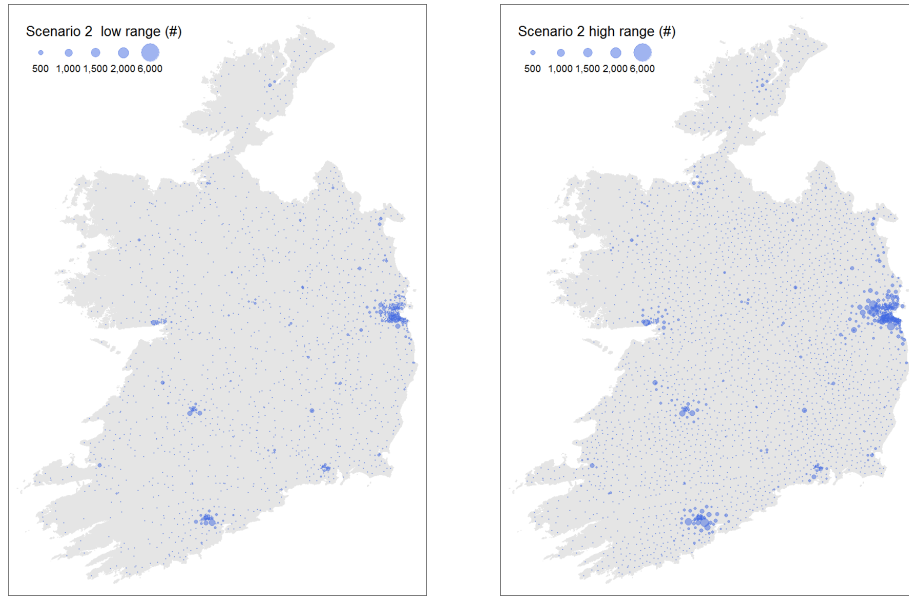
**Figure 1: Candidates for switching their second vehicle to a BEV based on Scenario 1 (weekly distance criteria and car ownership)**

## 299 3 Results

### 300 3.1 Distribution of candidates for switch to a BEV based on the scenarios described

301 The distribution of candidates for switching to a BEV based on commuting distance and ownership of  
 302 more than one car is studied in the first scenario. The calculation also considers EV battery capacity  
 303 concerning the distance covered from a single recharge at two levels. We identify hotspots mainly around  
 304 cities in Ireland where a large concentration of potential buyers is present. Figure 1 shows the distribution  
 305 of candidates based on these criteria at two different ranges attained by common EVs in market. Based  
 306 on the lower EV range, i.e. 310km, an estimated 194,000 candidates could comfortably complete their  
 307 weekly car trips on a single charge. This figure is almost 4 times the number of EVs in the existing car

<sup>8</sup> The generation of electricity implies emissions too (60g per km indirect emissions attributed to electricity generation for electric vehicles (SEAI, n.d.)). However, the reduction emissions in this sector are regulated through the EU Emissions Trading System and not via transportation policies.



**Figure 2: Candidates for switching their second vehicle to a BEV based on scenario 2 (socio-economic characteristics and commuting patterns based on weekly distance calculations)**

308 fleet. Based on a high range EV (i.e. 436km) the number of candidates is 481,000. As mentioned earlier,  
 309 the calculation is conservative and focuses on vehicle owners with two vehicles so EV range anxiety is  
 310 not necessarily a factor in occasional longer trips. Table 3 provides the vehicle penetration rate where  
 311 the base is the total number of vehicle owners who drives to work. Approximately 17 to 42% of vehicle  
 312 owners could comfortably satisfy existing weekly transport needs on a single charge of an EV. Table  
 313 A.3 provides a list of high-density areas which are at the 99th percentile or above for aggregate count of  
 314 potential adopters as per scenario 1. The higher density of potential adopters are found in Dublin, Cork  
 315 and Limerick counties. Douglas in Cork and Blanchardstown-Blakestown in Fingal have the highest  
 316 number of candidates for switch to a EVs.

317 Under scenario 2, where socio-economic characteristics are also considered, we see that the pen-  
 318 etration rates for EVs are substantially lower at between 3% and 8% for low and high battery ranges  
 319 respectively (as per table 3). Similar to Morton et al. (2018) for the UK, we identify potential hot spots  
 320 for EV substitution in both urban and rural areas. Rural areas with pockets of high density of potential  
 321 candidates are in Meath, Kilkenny and Kerry. Figure 2 shows the distribution of candidates for EV sub-  
 322 stitution based on these criteria at two different ranges attained by common EVs in market. The electoral  
 323 areas with the highest number of candidates for EV substitution are Lucan-Eskar in Dublin, Douglas in  
 324 Cork and Blanchardstown-Blakestown in Fingal.

		Scenario 1		Scenario 2	
		Low range	high range	low range	high range
Direct emission reduction	Emissions (kt)	367	1073	65.8	213.3
	Share (%)	12.6	36.9	2.2	7.3
	Average (t)	1.88	2.23	1.89	2.26

Note: Emission share out of 2906.72 kt emissions (from 1,154,469 car owners who drive in the sample)

**Table 4: Reduction in CO<sub>2</sub> emissions and their share out of total emissions in different scenarios. Values in kilo tonnes (kt) and in %**

		Total emissions (kt)	Scenario 1		Scenario 2	
			Low	High	Low	High
Rural	Emissions (kt)	1,156	36.7	362	5.7	67.2
	share (%)		3.2	31.3	0.5	5.8
	Average (t)	2.90	1.98	2.42	1.99	2.45
Urban	Emissions (kt)	1,750	330.4	711.05	60.2	146.2
	share (%)		18.8	40.6	3.4	8.3
	Average (t)	2.30	1.87	2.14	1.88	2.18

**Table 5: Emission reduction calculation from various scenarios in rural and urban areas**

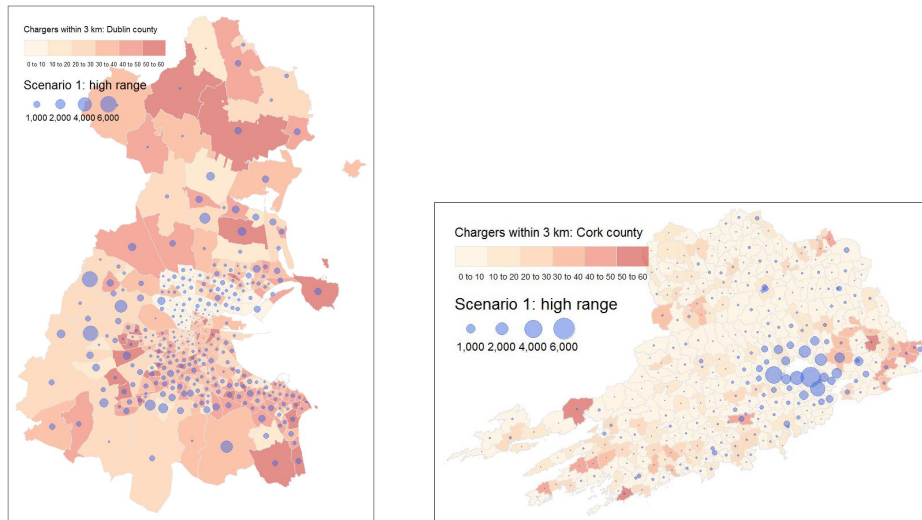
### 3.2 Emission reduction potential from switching

The aggregate emissions associated with each scenario is shown in table 4. We provide the results across the two proposed scenarios and EV battery ranges. We estimate aggregate and average potential emission savings from a transition to EV. As per scenario 1 for high range EV the emission savings can be as high as 1073 kt if we consider tailpipe emissions. The first set of rows in table 4 shows that the direct emissions savings range from 2.2% to 36.9% from the emissions generated by vehicle owners who own at least one conventional vehicle. The average emissions in each scenario indicates that improving battery capacity will improve adoption of EVs by drivers of longer distances, which eventually will increase the emission savings further (shown in table 4). We further differentiate emissions from rural and urban areas as well (shown in table 5). The emission savings can be as high as 711 kt in the case of urban areas if we consider only direct emissions or 60.2 kt with more restrictive assumptions. This comes up to a substantial reduction of 40.6% of total emissions from vehicles owners in urban areas. Hence targeting just urban areas for expansion of charging network and messaging in the initial stages can yield significant emission reduction as per our estimation. While urban areas can have the largest environmental savings due to the higher aggregate EV adoption potential as per our scenarios, the average emission in rural areas is higher than urban areas<sup>9</sup>. The average emissions in rural areas are 26% higher than in urban ones (shown in table 5). If we aggregate emission reduction from transition to EV in Dublin county as a whole and Cork county, they jointly account for almost half of the emission reduction which can be achieved (shown in

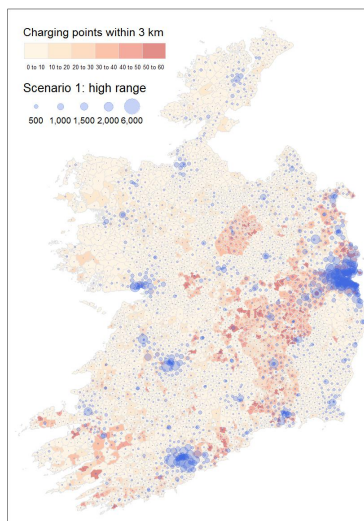
<sup>9</sup> The average distance travelled by drivers in rural and urban areas are 359 and 317 km as per our estimation.

343 table A.4). This again shows that targeting the urban areas with hotspots of candidates for messaging can  
344 significantly reduce emissions with existing infrastructure.

### 345 3.2.1 Charging infrastructure around candidate hotspots



**Figure 3: Distribution of candidates for switching their second vehicle to a BEV as per scenario 1 and proximity to charging points in Dublin and Cork**



**Figure 4: Distribution of candidates for switching their second vehicle to a BEV as per scenario 1 and proximity to charging points in Ireland**

346 Based on the results from previous sections, we zoom into the urban areas with higher density of  
347 candidates for switch to a BEV (shown in figure 3). Since the urban area population might be residing

348 in apartments without adequate charging infrastructure, we chart the density of charging points within 3  
349 kms of EDs within these areas. In figure 3 polygons with darker shading shows areas with high density of  
350 proximate charging points. Overall charging network in Dublin is better than other areas in the country.  
351 Even within Dublin county, there is significant heterogeneity when it comes to density of public EV  
352 charging infrastructure. From panel 1 in plot 3 there are areas with high density of candidates with lower  
353 density of charging infrastructure. However, considering the existing infrastructure within Dublin, non-  
354 traditional early adopter categories can be targeted for messaging related to EVs. Urban areas other than  
355 Dublin lack the density of charging infrastructure compared to Dublin, for example in Cork county as  
356 shown in panel 2 of figure 3. Overall charger density in Ireland with distribution of candidates for switch  
357 to a BEV is shown in figure 4. Targeted expansion of public charging networks in Cork, Limerick and  
358 Galway can attract non-traditional early adopters of EV.

## 359 4 CONCLUSION

360 The Climate Action Plan of Government of Ireland sets out ambitious targets for EV adoption in Ireland  
361 (Govt. of Ireland, 2019). However, the current EV adoption figures raise significant scepticism about  
362 achieving these targets. By using microdata on commuting behaviour and standardised assumptions  
363 based on existing literature, we identify the candidates for the switch to BEVs and compute the potential  
364 emission savings from such a switch. We find that there are between 194,422 and 481,077 cases where  
365 EVs could be substituted for internal combustion engine vehicles and comfortably satisfy weekly driving  
366 needs without the need to alter behaviour. This shows the potential which can be reached by targeting  
367 a wider population based on their commuting patterns rather than just the groups who are considered  
368 traditionally as ‘early adopters’ for messaging related to EV adoption. If we narrow down the candidates  
369 for substitution based on their fit to the profile of an early adopter as well, those figures drop dramatically  
370 to between 35,000 and 94,000. This therefore reflect the depth of challenge to reach policy targets.  
371 However, this still implies that the current number of 8,473 BEVs in Irish market could be at least 4 times  
372 larger.

373 Affordability is the main factor influencing the decision to purchase an EV for Irish citizens (CSO,  
374 Ireland, 2019). There are already several financial incentives to overcome such barriers, including pur-  
375 chase grants, Vehicle Registration Tax (VRT) relief, toll incentives, home charger installation grants and  
376 reduced motor tax rates. This research identifies geographical areas with a high density of potential candi-  
377 dates for switching their second vehicle to an EV. Such information is beneficial for targeted or localised  
378 promotion of EVs. While high level marketing of EV transition is necessary the identified hotspots where  
379 targeted or specialised efforts to encourage EV uptake might be most successful. Specialised initiatives  
380 could be established in these areas in addition to existing incentives. For example, local EV test drive cen-  
381 tres, sponsored local EV champions, etc can be organised in such areas. The research identifies locations  
382 in Dublin, Cork and Limerick as core areas (i.e. hot spots) where there is potential for greater diffusion  
383 of EVs. These locations are identified as having a high density of residents that can easily satisfy their



384 weekly travel needs based on a single battery charge, in essence without range anxiety concerns. The  
385 analysis focuses on multi-car owners, with the assumption that one car is potentially replaced with an  
386 EV. Range anxiety is often associated with occasional longer trips so for longer trips multi-car owners  
387 are not constrained to use their EV. In summary, the assumptions underlying the analysis are such that the  
388 potential EV switchers can continue all their usual travel patterns without any concerns regarding finding  
389 public EV charging points or delays there.

390 A significant reduction in transport emissions is feasible from switching to EVs. Many of the hot  
391 spots for EV switching in our scenarios are situated in urban areas. Emission savings associated with a  
392 single EV are relatively small but aggregate emission savings potential within such areas is substantial.  
393 While switching to an EV is a private decision for each vehicle owner and their household, the promotion  
394 of the collective emission reduction potential could be used as a motivation for more environmentally  
395 conscious groups to consider adoption of EVs.

396 Availability of charging points away from home and availability of overnight charging at low cost are  
397 also factors influencing decision to adopt EV technology as per [CSO, Ireland \(2019\)](#). The distribution  
398 of current charging stations infrastructure in certain hotspots such as County Dublin is already exten-  
399 sive. Hence such areas can be targeted for campaigns aiming for improving adoption rates among non-  
400 traditional adopters of EVs, like environmentally conscious younger individuals or apartment dwellers.  
401 Other urban areas such as county Cork could gain from improvements in charging infrastructure espe-  
402 cially near areas with clusters of candidates. In areas where there are fewer detached houses, Dutch-style  
403 free parking incentives coupled with expanded slow charging network in public parking areas can be  
404 an effective policy to accelerate adoption ([Globisch et al., 2019](#)). Campaigns that target the identified  
405 hotspots could create a multiplier effect because drivers are more likely to adopt EVs as EV adoption  
406 becomes normalised ([Noppers et al., 2019](#)).

## 407 **References**

408 CSO, Ireland. (2016). *Census of population 2016 - profile 1 housing in ireland*. Retrieved from  
409 <https://www.cso.ie/en/releasesandpublications/ep/p-cp1hii/cp1hii/od/>. (Accessed  
410 on 26/04/2021)

411 CSO, Ireland. (2018). *Census 2016 place of work, school or college - census of anonymised records*  
412 (*powscar*). Retrieved from <https://www.cso.ie/en/census/census2016reports/powscar/>.  
413 (Accessed on 18/02/2021)

414 CSO, Ireland. (2019). *National travel survey: Electric vehicles, 2019*. Retrieved from [https://  
415 www.cso.ie/en/releasesandpublications/ep/p-nts/nationaltravelsurvey2019/  
416 electricvehicles/](https://www.cso.ie/en/releasesandpublications/ep/p-nts/nationaltravelsurvey2019/electricvehicles/).

- 417 CSO, Ireland. (2021). *Road traffic volumes*. Retrieved from [https://www.cso.ie/en/  
418 releasesandpublications/ep-p-tranom/to2016/rtv/](https://www.cso.ie/en/releasesandpublications/ep-p-tranom/to2016/rtv/). (Accessed on 24/02/2021)
- 419 Department of Transport, Tourism and Sport. (2019). *Bulletin of vehicle and driver statis-  
420 tics*. Retrieved from [https://www.gov.ie/en/publication/0f943b-irish-bulletin-of  
421 -vehicle-and-driver-statistics-2019/](https://www.gov.ie/en/publication/0f943b-irish-bulletin-of-vehicle-and-driver-statistics-2019/). (Accessed on 10/03/2021)
- 422 ESB, Ireland. (2021). *Public ev charging points in ireland*. (Accessed on 18/02/2021)
- 423 Funke, S. Á., Sprei, F., Gnann, T., & Plötz, P. (2019). How much charging infrastructure do electric  
424 vehicles need? a review of the evidence and international comparison. *Transportation research part  
425 D: transport and environment*, 77, 224–242.
- 426 Globisch, J., Plötz, P., Dütschke, E., & Wietschel, M. (2019). Consumer preferences for public charging  
427 infrastructure for electric vehicles. *Transport Policy*, 81, 54–63.
- 428 Govt. of Ireland. (2019). *Climate action plan 2019*. Retrieved from [https://www.gov.ie/pdf/?file=  
429 https://assets.gov.ie/25419/c97cdecddf8c49ab976e773d4e11e515.pdf#page=null](https://www.gov.ie/pdf/?file=https://assets.gov.ie/25419/c97cdecddf8c49ab976e773d4e11e515.pdf#page=null).  
430 (Accessed on 15/03/2021)
- 431 Guerra, E., & Daziano, R. A. (2020). Electric vehicles and residential parking in an urban environ-  
432 ment: Results from a stated preference experiment. *Transportation Research Part D: Transport and  
433 Environment*, 79, 102222.
- 434 Haustein, S., & Jensen, A. F. (2018). Factors of electric vehicle adoption: A comparison of conventional  
435 and electric car users based on an extended theory of planned behavior. *International Journal of  
436 Sustainable Transportation*, 12(7), 484–496.
- 437 Karney, C. F. (2013). Algorithms for geodesics. *Journal of Geodesy*, 87(1), 43–55. Retrieved from  
438 <https://doi.org/10.1007/s00190-012-0578-z>
- 439 Kevany, L. (2019). *Spending review 2019, incentives for personal electric vehicle pur-  
440 chase*. DPER, Gov. of Ireland. Retrieved from [https://assets.gov.ie/25107/  
441 eb5a541e3b614c94a3e47c8d068e72c9.pdf](https://assets.gov.ie/25107/eb5a541e3b614c94a3e47c8d068e72c9.pdf). (Accessed on 15/03/2021)
- 442 McAleer, M. (2019, June 18). *Climate plan: 1m electric cars by 2030 does not look realistic*.  
443 *Irish Times*. Retrieved from [https://www.irishtimes.com/life-and-style/motors/climate  
444 -plan-1m-electric-cars-by-2030-does-not-look-realistic-1.3929310](https://www.irishtimes.com/life-and-style/motors/climate-plan-1m-electric-cars-by-2030-does-not-look-realistic-1.3929310). (Accessed on  
445 15/02/2021)
- 446 McCoy, D., & Lyons, S. (2014). Consumer preferences and the influence of networks in electric vehicle  
447 diffusion: An agent-based microsimulation in ireland. *Energy Research Social Science*, 3, 89-101. Re-  
448 trieved from <https://www.sciencedirect.com/science/article/pii/S2214629614000863>  
449 doi: <https://doi.org/10.1016/j.erss.2014.07.008>

- 450 Morton, C., Anable, J., Yeboah, G., & Cottrill, C. (2018). The spatial pattern of demand in the early  
451 market for electric vehicles: Evidence from the united kingdom. *Journal of Transport Geography*, 72,  
452 119–130.
- 453 Mukherjee, S. C., & Ryan, L. (2020). Factors influencing early battery electric vehicle adoption  
454 in ireland. *Renewable and Sustainable Energy Reviews*, 118, 109504. Retrieved from [https://](https://www.sciencedirect.com/science/article/pii/S1364032119307129)  
455 [www.sciencedirect.com/science/article/pii/S1364032119307129](https://www.sciencedirect.com/science/article/pii/S1364032119307129) doi: [https://doi.org/](https://doi.org/10.1016/j.rser.2019.109504)  
456 10.1016/j.rser.2019.109504
- 457 Namdeo, A., Tiwary, A., & Dziurla, R. (2014). Spatial planning of public charging points using multi-  
458 dimensional analysis of early adopters of electric vehicles for a city region. *Technological Forecasting*  
459 *and Social Change*, 89, 188–200.
- 460 Noppers, E., Keizer, K., Milovanovic, M., & Steg, L. (2019). The role of adoption norms and perceived  
461 product attributes in the adoption of dutch electric vehicles and smart energy systems. *Energy Re-*  
462 *search Social Science*, 57, 101237. Retrieved from [https://www.sciencedirect.com/science/](https://www.sciencedirect.com/science/article/pii/S2214629618311563)  
463 [article/pii/S2214629618311563](https://www.sciencedirect.com/science/article/pii/S2214629618311563) doi: <https://doi.org/10.1016/j.erss.2019.101237>
- 464 O’Sullivan, K. (2021, February 23). *Electrified vehicles see sharp rise in sales under new tax*  
465 *scheme. Irish Times*. Retrieved from [https://www.irishtimes.com/news/environment/](https://www.irishtimes.com/news/environment/electrified-vehicles-see-sharp-rise-in-sales-under-new-tax-scheme-1.4492165#:~:text=There%20were%20986%20EVs%20sold,per%20cent%20in%20January%202020)  
466 [electrified-vehicles-see-sharp-rise-in-sales-under-new-tax-scheme-1.4492165#:](https://www.irishtimes.com/news/environment/electrified-vehicles-see-sharp-rise-in-sales-under-new-tax-scheme-1.4492165#:~:text=There%20were%20986%20EVs%20sold,per%20cent%20in%20January%202020)  
467 [~:text=There%20were%20986%20EVs%20sold,per%20cent%20in%20January%202020](https://www.irishtimes.com/news/environment/electrified-vehicles-see-sharp-rise-in-sales-under-new-tax-scheme-1.4492165#:~:text=There%20were%20986%20EVs%20sold,per%20cent%20in%20January%202020). (Ac-  
468 cessed on 10/03/2021)
- 469 Pebesma, E. (2018). Simple Features for R: Standardized Support for Spatial Vector Data. *The R*  
470 *Journal*, 10(1), 439–446. Retrieved from <https://doi.org/10.32614/RJ-2018-009> doi: 10  
471 .32614/RJ-2018-009
- 472 Plötz, P., Schneider, U., Globisch, J., & Dütschke, E. (2014). Who will buy electric vehicles? identifying  
473 early adopters in germany. *Transportation Research Part A: Policy and Practice*, 67, 96–109.
- 474 Rigaux, P., Scholl, M., & Voisard, A. (2001). *Spatial databases: with application to gis*. Elsevier.
- 475 Saarenpää, J., Kolehmainen, M., & Niska, H. (2016). Identifying socio-demographically favourable area  
476 types for early hybrid electric vehicle adoption through mining of public sector data. *Intelligent Data*  
477 *Analysis*, 20(2), 339–355.
- 478 Sander, H. A., Ghosh, D., van Riper, D., & Manson, S. M. (2010). How do you measure distance in spatial  
479 models? an example using open-space valuation. *Environment and Planning B: Planning and Design*,  
480 37(5), 874-894. Retrieved from <https://doi.org/10.1068/b35126> doi: 10.1068/b35126
- 481 SEAI. (n.d.). *CO2 emissions*. Retrieved from [https://www.seai.ie/technologies/electric](https://www.seai.ie/technologies/electric-vehicles/why-drive-electric/the-environment/)  
482 [-vehicles/why-drive-electric/the-environment/](https://www.seai.ie/technologies/electric-vehicles/why-drive-electric/the-environment/). (Accessed on 15/03/2021)

- 483 SEAI. (2020). *Energy in ireland*. Retrieved from <https://www.seai.ie/publications/Energy-in-Ireland-2020.pdf>. (Accessed on 30/03/2021)
- 484
- 485 SEAI. (2021). *SEAI grant eligible cars*. Retrieved from <https://www.seai.ie/grants/electric-vehicle-grants/grant-eligible-cars/>. (Accessed on 18/02/2021)
- 486
- 487 Thøgersen, J., & Ebsen, J. V. (2019). Perceptual and motivational reasons for the low adoption of electric cars in denmark. *Transportation Research Part F: Traffic Psychology and Behaviour*, 65, 89–106.
- 488
- 489 Vassileva, I., & Campillo, J. (2017). Adoption barriers for electric vehicles: Experiences from early adopters in sweden. *Energy*, 120, 632–641.
- 490
- 491 Westin, K., Jansson, J., & Nordlund, A. (2018). The importance of socio-demographic characteristics, geographic setting, and attitudes for adoption of electric vehicles in sweden. *Travel Behaviour and Society*, 13, 118–127.
- 492
- 493
- 494 Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L. D., François, R., ... Yutani, H. (2019). Welcome to the tidyverse. *Journal of Open Source Software*, 4(43), 1686. doi: 10.21105/joss.01686
- 495
- 496 Zhuge, C., & Shao, C. (2019). Investigating the factors influencing the uptake of electric vehicles in beijing, china: Statistical and spatial perspectives. *Journal of cleaner production*, 213, 199–216.
- 497

498 **Appendix A I**

Vehicle type	Total fleet	Private cars
Petrol/ diesel and electric hybrids (HEV)	48,683	45,167
Electric (BEV)	9,120	8,473
Plugin hybrids (PHEV)	6,427	6,305

**Table A.1: Electric vehicle fleet in Ireland as of 2019 (Department of Transport, Tourism and Sport, 2019)**

	Sensitivity analysis			
	Scenario 1		Scenario 2	
	Low range	High range	Low range	High range
Count	378,269	487,948	71,987	95,865
Share (%)	32.7	42.2	6.2	8.3

Note: share out of 1,154,469 (car owners who are drivers)

**Table A.2: Aggregate count of potential buyers as per the sensitivity analysis scenario**

	ED	County	Scenario 1 high range
1	Blanchardstown-Blakestown	Fingal	5,553
2	Douglas	Cork County	5,335
3	Lucan-Esker	South Dublin	5,269
4	Ballincollig	Cork County	3,740
5	Castleknock-Knockmaroon	Fingal	3,360
6	Glencullen	Dún Laoghaire-Rathdown	3,126
7	Ballycummin	Limerick City and County	2,954
8	Carrigaline	Cork County	2,808
9	Swords-Forrest	Fingal	2,545
10	Bearna	Galway City	2,495
11	Naas Urban	Kildare	2,482
12	Firhouse Village	South Dublin	2,397
13	Lehenagh	Cork County	2,340
14	Celbridge	Kildare	2,334
15	Leixlip	Kildare	2,287
16	Ennis Rural	Clare	2,242
17	Ballysimon	Limerick City and County	2,221
18	Kilkenny Rural	Kilkenny	2,114
19	Firhouse-Ballycullen	South Dublin	2,037
20	Navan Rural	Meath	2,025
21	Caherlag	Cork County	1,840
22	Rathcooney (Part Rural)	Cork County	1,808
23	Tallaght-Jobstown	South Dublin	1,791
24	Dunboyne	Meath	1,735
25	Kilmacanoge	Wicklow	1,724
26	Tralee Rural	Kerry	1,688
27	Maynooth	Kildare	1,570
28	Lucan-St. Helen's	South Dublin	1,569
29	Ballybaan	Galway City	1,560
30	Swords-Lissenhall	Fingal	1,523
31	Kinsaley	Fingal	1,469
32	Donaghmore	Meath	1,429
33	Tramore	Waterford City and County	1,425
34	Morrinstownbiller	Kildare	1,423
35	Ashtown A	Dublin City	1,405

**Table A.3: EDs with 99 percentile count for potential adopters as per Scenario 1 high range**

County	Emission reduction Direct (kt)	
	Scenario 1	Scenario 2
Cork County	127.4	26.8
South Dublin	84.7	17.5
Fingal	82.05	18
Dublin City	76.1	15
Dun-Laoghaire Rathdown	61.2	17.6
Kildare	52.9	10.9
Limerick City	45.4	8.9
Galway County	41.8	9.4
Meath	40.1	7
Kerry	32.5	5.7
Tipperary	32.4	5.2
Wexford	31.4	5
Clare	30.3	6
Waterford City	29.2	6.1
Donegal	29.1	5.2
Mayo	28.2	4.7
Wicklow	26.7	5.4
Kilkenny	25.3	4.9
Louth	23.7	4.3
Cork City	23.6	4
Westmeath	17.9	3.3
Galway City	16.5	3.5
Sligo	16.1	3.6
Laois	15.9	2.5
Cavan	15.8	2.3
Roscommon	14.5	2.5
Offaly	14.3	2.2
Monaghan	13.8	1.9
Carlow	10.9	1.8
Longford	7.1	1.1
Leitrim	6.1	1.1

**Table A.4: County wise tailpipe emission reduction in each scenario considering a high range EV being adopted**

		Sensitivity analysis			
		Scenario 1		Scenario 2	
		Low range	high range	low range	high range
Direct emission reduction	Emissions (kt)	452	725	88.8	148.4
	Share (%)	15.5	24.9	3.05	5.1
	Average (t)	1.19	1.48	1.23	1.54

Note: Emission share out of 2,906.72 kt emissions (from 1,154,469 car owners who are drivers in the sample)

**Table A.5: Reduction in CO<sub>2</sub> emissions and their share out of total emissions in different sensitivity analysis scenarios. Values in kilo tonnes (kt) and in %**