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Electric Vehicles for Smart Cities

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ABSTRACT

We need to decarbonize municipal energy systems in order to meet our climate commitments. We examine the implications of integrating battery-powered cars and buses into the city's energy system, taking into account local heat generation and storage, electricity imports into the city, and investment potential to reach net-zero emissions from local electricity and heating by 2050. Our research indicates that up to 85% of the demand for charging electric vehicles is intermittent, and smart charging technologies can allow 62% solar PV to be included in the energy mix for charging, up from 24% when cars are charged directly while parked. Due to their tight schedules, solar PV can only supply about a third of the energy used by electric buses.The advantages of smart charging for the municipal energy system may be utilised when charging is done in accordance with the local price of power in the city. When cars can be charged in an efficient manner, there is no need to invest in fixed batteries and peak units in the urban energy and heating sectors. Our findings highlight the significance of integrating several sectors to give urban regions the greatest flexibility possible in regards to things like transportation, heating, and power.

Keywords:Electric vehicle, Smart city, Electric buses, Vehicle-to-grid, vehicle-to-vehicle, Genetic algorithm, Energy, Smart city, Multi-objective, Evolutionary algorithm, Charging stations, Partial charging, Energy consumption

1.Introduction

The majority of the world's rapidly expanding population now resides in cities. Because of this expansion, there is a higher need for electricity, gas, and water for domestic and public use, as well as for heating and cooling. a significant roadblock to city planning. Thus, it will be essential to make sure that programs for the urban system's attempts to meet these rising requirements are compatible with dependable long-term goals to reduce global warming. Increasingly self-sufficient and less dependent on the national power grid's imports of energy, towns with growing electrical demands can develop and adapt through time. Often related to the development of new electricity cables linking to the national electrical grid. Utilizing storage flexibility is a result systems, adaptable demands, and sectoral integration at the city scale along with regional energy and heat supply are anticipated to be an vital component of a completely carbon-free energy system. The term "smart city" refers to the integration.

2. Literature review

In order to reach climate goals, municipal energy systems must be decarbonized. We employ three distinct charging procedures in a modelling tool that takes into account local generation and examines the effects of integrating electric vehicles and buses into the city energy systemimporting power into the city, storing electricity and heat, and making expenditures to attain net-zero emissions fromLocal heating and electricity in 2050. We discover that up to 85% of the demand for electric vehicle charging is62% of the charging electricity mix can be made possible by solar PV thanks to flexible and clever charging solutions.[1]

Over the coming decades, a major factor in lowering air pollution in densely populated places will be the widespread use of electric vehicles in urban areas. This will entail a shift in the energy demand away from the oil industry and toward electric energy utilities, necessitating the creation of a sufficient infrastructure for charging electric vehicles. In addition, the entire future smart city integration of electric vehicles will necessitate the creation of new vehicle-to-grid applications.Allowing for dynamic interaction between the users and grid operators and the cars. This essay's objective is to illustratehow to construct a smart charging infrastructure using driving patterns and data mining, as well as how to locate Vehicle-to-Grid hotspots across huge geographic.[2]

A major issue in smart cities is the implementation of a charging infrastructure to handle the rising demand for electric cars (EVs). Additionally, as soon as people have access to adequate charging stations, the penetration of EVs will rise. In this paper, we address the issue of finding a collection of charging stations in a smart city taking into account diverse data sources like open data cityportals, geo-located social network information, and substations for power transformers. Our method is multi-objectiveusing a genetic algorithm to maximise utility and minimise cost, charging station sites can be improvedthe price. Our hypothesis is supported by a case study and various experimental findings.[3]

Future "smart cities" that incorporate the Internet of Vehicles (IoV) could help with a number of traffic-related issues, including lowering traffic congestion and accidents. Various policies for charging electric vehicles and congestion pricing have been implemented recently. However, most of these ideas failprioritise imposing fines on automobiles who choose to use congested highways or crowded charging stationsand refrain from rewarding the cars that abide by the traffic control system. In this essay, we suggest asystem for managing electric vehicle charging and new dynamic traffic congestion pricing for the internet ofcars in a setting of a metropolitan smart metropolis. The suggested methodcompensates drivers who choose to use alternativefree of congestion roads and charging points.[4]

The anticipated rise in electric vehicle (EV) sales in the upcoming years will aid in the reduction of CO2 emissions in our cities. Currently, long charging times and overcrowded charging stations may cause EV consumers distress (CSs). Critical traffic situations, such as gridlock, have an impact the total travel duration is influenced by the EVs' trip times (TT) to CSs. In light of this worry, Intelligent connected vehicle technologies, more specifically transport systems (ITS), can benefit from an effectivereal-time EV charging service by simultaneously taking into account the city's traffic situation and the state of the CSs.[5]

Today, many countries are driven to use technology to deliver services and alleviate urban challenges due to population expansion, air pollution, and energy shortages. The concept of a "smart city" enables direct communication with urban infrastructure and real-time monitoring of activity. A smart city is one that is built ontechnology for information and communication. This article discusses how an electrical transportation system should operate.Various resources for energy distribution have been investigated. In a smart city, the main energy-consuming systems areelectric rail systems and electric vehicles in power systems are two examples of electrical transportation systems. utilises a linear model for co-optimization running of the subway system.[6]

In order to increase the cruising range for Electric Vehicles (EVs) on road networks, the issue of minimising the overall trip time—taking into account the time spent at charging stations—is studied in this research. EVs must inevitably stop at recharge points because of their limited battery capacity. They are deficient, and the process of recharging is planning a route effectively takes time and is crucial. This paper expands on a prioroffered strategy, namely EVRC (Electric Vehicle Route Planning with Recharging). In depth,the answer offered in this paper takes into account a number of aspects at onceand presents a practical method for calculating time-optimal routes for road networks.[7]

3. Methodology

To improve the social, economic, or environmental performance of various city actors and sectors through the application of infrastructure and communication technology. When planning for decarbonization at the city scale, it's important to think about the complementary sectors and technologies that may work together. options and paths for urban energy change. Solar and wind power, which are both carbon-free and boost a city's energy independence, may be placed on-site inside the energy infrastructure of a city because of their modular design. In highly populated areas, solar PV is more readily accepted than wind energy since there are less disruptions. Cities may make technological strides through the coordinated use of variable renewable energy (VRE) sources. Charging the batteries of electric vehicles or other energy storage equipment. Due to variations increasing the value of the flexible operation of the heat supply and reducing the marginal costs for electricity production or heat pumps, significant shares of VRE may have an effect on the use of combined heat and power to runcity district heating systems. The consumption of fuel can be eliminated by using power to heat homes and public district heating systems with inexpensive energy. The ability to use electricity for one's ownneeds with VRE has been demonstrated to grow with the usage of tank or pit storage units. This isparticularly true when usingpower-to-heat (PtH) technologies like heat pumps and thermal energy storage systems (TES), which can includeelectric boilers.

None of the aforementioned studies have made use of a modeling tool developed specifically to investigate decarbonization; this tool would allow for the inclusion of hourly temporal resolution, local electricity and heat storage and other factors. In Figure, we see a diagram of the municipal energy system optimization model, which depicts heating and electrical needs and the potential for importing electricity from the national grid, subject to the limitations imposed by connection capacity, Investment and operation of regional heating and electricity production, storage, and electrification of the city's transportation industry. Using city-level situations and links between industries as an example. In this work, we build and apply this type of modeling tool to optimize the city's energy system model, which was first made public to delve into the connections between BECs, BEB's, and the municipal energy. We model the city's BEC and BEB charging infrastructure, taking into consideration three unique BEC charging patterns, and compare and contrast the resulting scenarios:

1. Fixed charging, in which vehicles are immediately charged upon arrival.

2. Smart charging, whereby charging id adapted to the city energy system.
3. Smart charging with V2G.

For BEBs, we apply our strict and savvy pricing policies. Since the BEB fleet has a greater electrical demand and lower battery capacity then the BEC fleet, this section details the after-effects of a citywide integration of BECs on the administration of energy and the subdivision of the district heating sectors. the findings of this study contribute to a deeper appreciation of the here and now:

- the results of smart charging and flexible charging's incorporation into the city's energy grid for BECs and BEBs.
- What different pricing strategies impact BEB and BEC ability to use low-carbon power generated on-site.
- Discusses how different BEC pricing schemes influence the proper functioning and construction of the electric and district heat sectors in a municipal energy system that uses sector-coupling.

The primary objectives of this research are to examine the viability of utilizing local generation and storage, and to examine the synergies that may exist between electric vehicles and the city's district heating and electrical systems. Incorporating charging buses that can accommodate a variety of electric car configurations. Rather of trying to copy pre-existing energy markets, it is preferable to replicate the city's energy system's efficient operation.

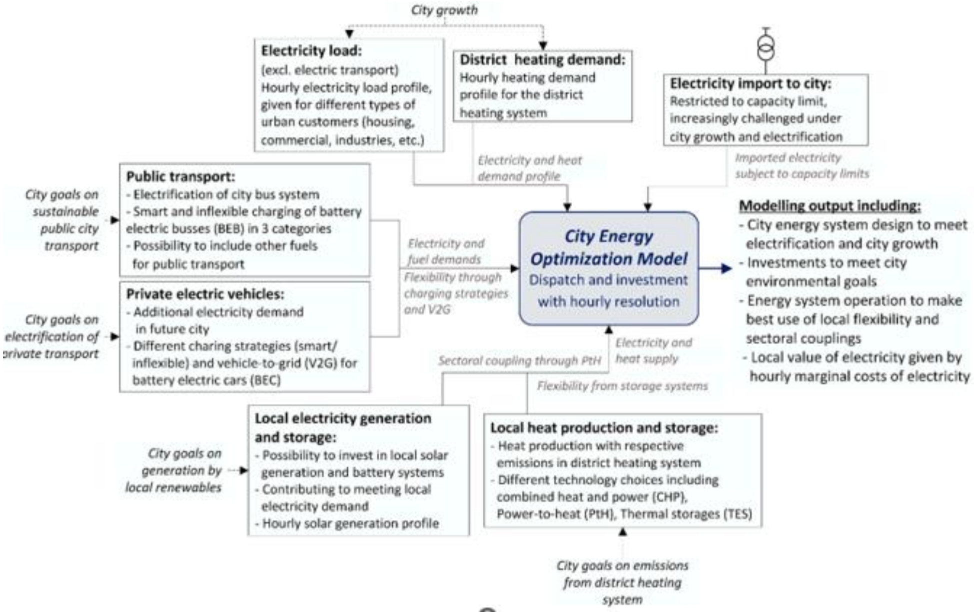


Fig1: Outline diagram of EVs

4. Working and operation

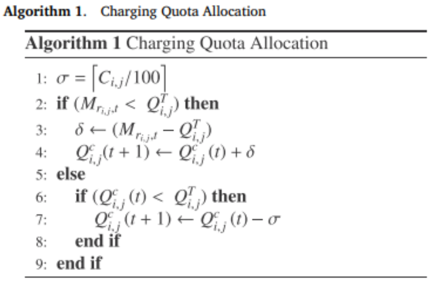
Demand for energy, design of the recharge infrastructure, and evaluation of V2G

TEMA simulates the actions of automobiles to determine the impact on the power grid of converting a certain percentage of urban vehicles to EVs. These estimates are then extrapolated to Italy's wholecar fleet to assess the countrywide effect of EVs on the powergrid (Paffumi, et al., 2015a). In the same way that the anticipated energy demand is geo-referenced based on the GPS locations of the parking events associated with the recharges, so too is the actual energy consumption. By analyzing the electric energy demand across the region under study and comparing it to the current recharging infrastructure as well as determining where charging stations must be situated to meet this need, a customer-driven recharge infrastructure can be designed.

It is now much simpler to georeference findings because to the dynamic interfacing of activity databases with web-based digital maps (Google Inc., 2013). The area of the province of Modena, which totals 7391 [km], is split into about 29,500 squared terrain tiles of 0.25 km on the map, and the energy demand is presented across this rectangular study frame (500 meters per edge). Electric energy consumption associated with each tile is integrated in space and time to produce the daily and monthly averages, which are then interfaced to a network of points of interest (POI) that are viewed as potential future locations for charging stations. From the POI plaza website, five distinct datasets of POIs have been collected (2014). of Italy's around 35,590 POIs, 423 are located within theprovince of Modena. Then, using a distance-based criterion based on the presumption that a recharge can only be relayed to a POI if it occurs within a distance of up to 1 [km], the power demand from BEVs' recharging events is linked to the POIs. The Repeatability Index, which is the number of plugged-in vehicles, and the Geographic Key Performance Indicator (KPI), which is an averaged indicator of the POI's ability to meet charging requests for urban vehicles in terms of geographic location, are provided for each POI and allow for the transmission of a weighted energy demand to all relevant POIs while hiding the customers' final choice is less than 100m, equals 0 if it exceeds 1 [km], and scales linearly from 1 to 0 in all other cases). These three factors, which also include the number of plugs and the necessary amount of electricity at each POI, determinethe size of the recharging infrastructure network.

Managing EV charging quotas

The total number of charging spots on the CS is divided into two categories, just like on the road (the free charging quota and the paid charging quota). EVs wishing to use the CS after the free charging limit has been reached will have to pay a set amount of tokens. The free charging allowance may be reserved without the use of tokens. Based on the demand for charging in previous time periods, the capacity of your paid charging plan changes dynamically. As the requirement for charging increases, so does the amount allocated for paid charging. We propose an algorithm for allocating charging quotas as a representation of dynamic management of charging quotas. The proposed technique improves upon the congestion management mechanism used by TCP. Our proposed technique, the CS's Additive IncreaseMultiplicative Decrease, is analogous to the road in that: (AIMD).



Algorithm 1. Charging Quota Allocation

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$\sigma = \lceil C_{i,j}/100 \rceil$
if ($M_{r_{i,j},t} < Q^T_{i,j}$) then
    $\delta \leftarrow (M_{r_{i,j},t} - Q^T_{i,j})$
    $Q^c_{i,j}(t+1) \leftarrow Q^c_{i,j}(t) + \delta$
else
    if ($Q^c_{i,j}(t) < Q^T_{i,j}$) then
        $Q^c_{i,j}(t+1) \leftarrow Q^c_{i,j}(t) - \sigma$
    end if
end if
```

As QiTj represents the threshold for paid charging quotas, it is a fixed figure that serves to highlight the constraints of paid charging quotas when charging demand exceeds this level. The present CS's paid charging limit will grow dynamically in response to future charging demand. The current QiCj paid charging quota. We have set the additive growth parameter, denoted by, to be equal to 2% of the CS's total charging capacity, and the multiplicative reduction parameter, denoted by, to be the number of EV's utilizing the paid charging quota.

Evaluation parameters

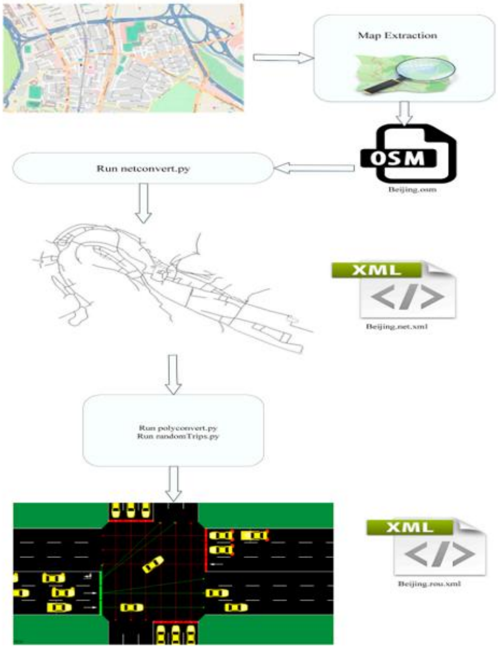

Fig 2: pictorial representation of algorithm

When assessing performance, we quantify the positive and negative effects of increasing EV density. The density of electric vehicles (EVs), defined as the total number of EV's in the simulated scenario, is the most crucial variable because of the impact it has on gridlock. Each time we run tests under different EV density levels and analyse the effect on the system's performance, we can better understand how well the system scales and performs in situations of heavy EV traffic. In order to perform the simulation, we used data from Open Street Map, which features a real-life map of Beijing (OSM). Since we needed a sizable area in which to analyse the performance with several EVs and widely spaced CS, we produced a map of 5km2 using the GPS coordinates of the location. In order to obtain the road data, the raw data from the OSM city map is needed. However, the CS details were released later because certainlocations lack any CS at all. Electric car traffic generation is performed using the simulation of Urban Mobility (SUMO) platform.

5. Conclusion:

In this research, we introduce an innovative smart city environment and Internet of Vehicles-based congestion pricing and electric vehicle charging management system. In the proposed scheme, electric vehicles that avoid the most congested highways and charging locations are rewarded with tokens. We propose a token-based charging economy in which cars earn tokens for taking shorter, less-trafficked routes to charging stations, and then use those tokens to cover the cost of charging. Tokens used in the tender process between cars double as charging tokens to control the charging reserve and the road reservation.

In order to alleviate traffic during rush hour, the proposed solution employs variable pricing. Through thorough traffic modeling in a variety of smart city situations, it has been shown that the technology may reduce congestion and the overall charging time at the charging station. We have left open a number of potential improvements to the proposed framework, though:

1. 1. In the current study, we propose integrating the We refer to the static management of the traffic light as the dynamic traffic light management system with the EV charging management system.
2. The server plays a key role as a traffic centre in the proposed architecture. Redesigning the server as a distributed vehicular server, in which the EV performs the server's processing duties, is a promising avenue for further study.

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