# PBCharge: Pure Chain-Based Smart Charging Framework for Electric Vehicles

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***Abstract*—In attempts to utilize green-energy, various frameworks and paradigms are being studied and proposed particularly for electric vehicle systems. This paper introduces PBCharge, a decentralized Smart Charging System for Electric Vehicles (EVs) utilizing blockchain technology, PureChain. The aim is to establish a decentralized charging infrastructure that incentivizes EV owners for participating by providing a system which has dynamic charging as well as rewarding users tokens when performing specific charging set-ups. Participants in this system include EV Owners, the Smart Charging System (SCS), and the Blockchain. Through smart contract functions, the SCS dynamically adjusts charging rates, with token rewards exclusively granted for either off-peak charging, or the use of renewable energy, or both conditions. Future works aim to include vehicle-to-grid capabilities in the smart charging system functions.**

***Index Terms*—Blockchain, electric vehicle, smart charging system**

## I. Introduction

As the adoption of electric vehicle (EV) systems grows, the need to establish secure and private interactions between EV owners, the Smart Charging System, and the underlying blockchain becomes imperative. This challenge extends beyond mere transactional security, encompassing the intricate balance between user authentication and safeguarding sensitive information. As instances have occured wherein electric charging stations have leaked drivers' data through their charging system database [1]. Privacy concerns loom large, prompting an exploration into sophisticated mechanisms that not only authenticate users seamlessly but also shield their personal data from unauthorized access. Addressing these privacy challenges is fundamental to the successful implementation and widespread acceptance of a Blockchain-based Decentralized Smart Charging System. By utilizing Pure Wallet's [2], developing technology, Proof-of-Authority may be utilized to create a decentralized charging system which continues to validate the blockchain at certain periods of time. This is aligned with the users which will be assumed to take part in the network and will be performing their respective functions accordingly.

Motivated by the previously discussed issues experienced in this field, this research aims to develop a:

1) To develop PBCharge: a PureChain-based smart charging system which allows for a decentralized system where EV owners' data are secure and they are rewarded for charging during grid off-peak demand time and use of renewable energy resource.

## II. Problem Formulation

The problem of existing electric vehicle charging systems are the long charging times which causes the grid to experience increase in loads in the distribution grid [3]. As such, encouraging users to schedule their EV charging and rewarding them during off-peak times allow for better grid load profile and is expected to alleviate the stress experienced by the grid, while being able to reward users for active participation in their scheduling of EV charging. With the use of distributed scheduling, there are multiple ways for the distribution grid to decrease the stress and allow end-users to enjoy cheaper rates [4]. As discussed in [5], the importance of the smart grid's activity to remain online is of importance, hence it is being addressed in this study.

## III. Proposed Scheme

In this current iteration of the work, the conditions for incentivizing the users are fixed to create a simple set-up of the expected simulations. In the case of rewards, there is a set time-window for. As this is a preliminary work, the intended purpose of this time window is to be a prototype set-up which integrated with AI-based training and prediction on expecting real-time. However, in this work, the main target is to identify the scheduling and the effect of the blockchain, hence the integrity of the blockchain is the one being focused, and its ability to reward its users are being discussed.

### A. System Framework

The overall framework of this study may be seen in Fig.1. Wherein the two participants, EV Owner is shown their determined functions as well as the blockchain-based smart charging system (SCS) which validates and distributes the transaction based on the criteria being done by the EV Owner. Once the criteria has been met, the EV owner calculates the incentives which is expected to be received, while the BC-based SCS is able to distribute the incentives accordingly.

### B. Smart Contract Functions

Participants in this blockchain set-up are then defined as three: EV Owner, the Smart Charging System, and the Blockchain. The functions of each participant is defined accordingly. The EV Owner is able to schedule a charge for the EV with the scheduleCharge() function, another function is to calculate the rewards if the owner is able to reach the

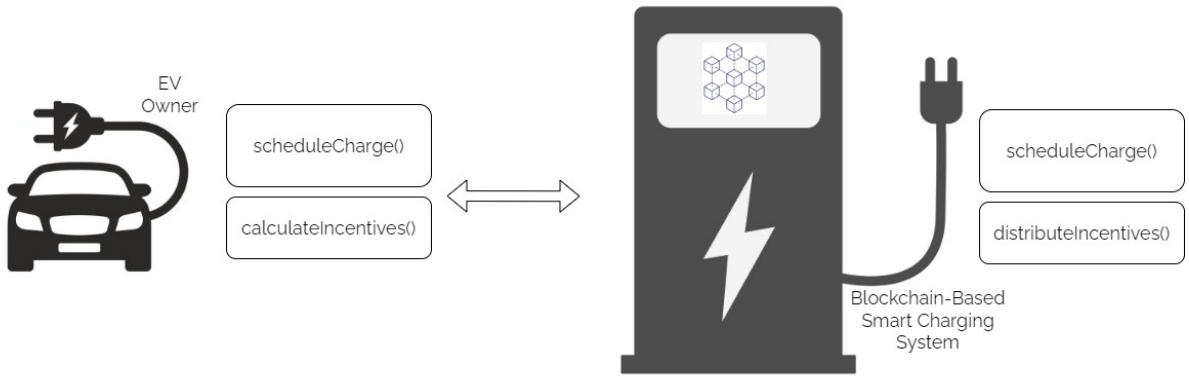


Fig. 1. PBCharge Framework

criteria in which they will be incentivized depending on the conditions set by the blockchain and the network by use of calculateIncetives() function. The SCS also validates the scheduled charge if the system is able to supply the declared schedule, the SCS also adjusts the charging rate depending on the time conditions at which the EV is being charged, and finally the SCS is able to distribute the incentives once the necessary conditions have been met. Finally, the blockchain is able to verify transactions, distribute the incentives, check the log of the charging events and confirm the charging rate adjustments.

The preliminary research of this work aims to create a framework in which the defined modules of the system may be intercharged and adjusted with respect to state-of-the-art technologies such as adaptive real-time off-peak loading and scheduling. For the blockchain, adaptive rewards system is being targeted and the adaptability of the blockchain to reward depending on the criteria that has been met. Since the system is to be deployed in a private network and the number of rewards would be computed individually, there must be testing of the blockchain utilizing the Proof-of-Authority, in which it is compared in this study.

## IV. Performance Evaluation

The metrics of this study which are to be tested and evaluated are on the areas of:

1) Blockchain generation - ability of the system to generate hash for each scheduled charge.
2) Blockchain security - test the blockchain's ability to remain decentralized and not compromise the user's data.
3) Incentives Integrity - the ability of the system to maintain incentivizing users who are able to meet the rewards criteria without taking over or destroying the reliability of the blockchain.

## V. Conclusion

This work is able to create a decentralized framework rewarding users to charge during a set time. Rewarding users which utilize this function, encourages the increase of off-peak charging and gives the users the freedom to determine at which rates they are able to charge their EVs. Making use of a scheduler and charging system, allows for users to enjoy and be rewarded of what they are using. The expected metrics of evaluation are the blockchain generation, in which the generated hash for each scheduled charge is expected to be maintained, and the integrity of the incentives being rewarded as such not to have a biased and maintain a reliable blockchain. Future works of the system aim to include vehicle-to-grid capabilities for the smart charging system functions.

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