Coordinated Energy Management Of Smart Parking lots for Plug-in vehicles

Major Project Report
(Part II)

Submitted in Partial Fulfillment of the requirements for semester IV of

MASTER OF TECHNOLOGY
IN
ELECTRICAL ENGINEERING
(Electrical Power Systems)

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CERTIFICATE

This is to certify that the Major Project Report (Part-II) entitled “”Coordinated Energy management of Smart parking lots for Plug-in vehicles” submitted by Mr. Kunal Lakhani (15MEEE11) towards the partial fulfillment of the requirements for Semester-III of Master of Technology (Electrical Engineering) in the field of Electrical Power Systems of Nirma University is the record of work carried out by him under our supervision and guidance. The work submitted has in our opinion reached a level required for being accepted for examination. The results embodied in this major project work to the best of our knowledge have not been submitted to any other University or Institution for award of any degree or diploma.
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Undertaking for Originality of the Work

I,Kunal Lakhani (Roll.No.15MEEE11), give undertaking that the Major Project entitled "Coordinated Energy Management Of Smart Parking lots for Plug-in vehicles" submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in Electrical Power Systems of Nirma University, Ahmedabad, is the original work carried out by me and I give assurance that no attempt of plagiarism has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere; it will result in severe disciplinary action.

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Acknowledgement

”The success of any task lies upon the efforts made by a person but it cannot be achieved without co-operation of others.” “With immense pleasure, I would like to present report on ”Coordinated Energy Management Of Smart Parking lots for Plug-in vehicles”. I am very thankful to the people who provided the necessary guidance during the work. With pleasure I now have the opportunity to express my gratitude towards them.

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Abstract

The solution for handling energy issues is using electric transport. Powerful coordination of module electric vehicles (PEVs) into the network is vital in the procedure of accomplishing practical improvement. One of the key arrangements with respect to the requirement for charging stations is the establishment of PEV parking garages (PLs). Parking lots for PHEVs are used to charge the vehicle batteries and thus enhance the drivers,drive their vehicles efficiently.Here, particle swarm optimization(PSO) method is used to find out the best solution.

Abbreviations

h_{start}=**start charging time**
h_{end}=**end time of charging**
h=**hour**
N^{PEV}=**number of parked PEVs**
$N^{PEV,arv}$=**number of PEV arrivals**
$N^{PEV,dep}$=**number of PEV departures**
${N_{t-1}}^{PEV}$=**number of PEVs in the previous hour**
t^{arv}=**time of arrival**
t^{dep}=**time of departure**
TOU=**time of use**
aer_v=**all electric range of vehicle in km**
d_v=**distance between home and parking lot**
df_v=**derating factor of vehicle(figure 5.1)[14]**
itr=**iterations**
Pin_{vt}=**input power**
$Pout_{vt}$=**output power**
$Prat_v$=**rating of vehicle**
$SOCch_{vt}$=**SOC of charging of a particular vehicle at a particular time**
$SOCdch_{vt}$=**SOC of discharging of a vehicle**
$SOCin_v$=**input SOC**
$SOCdep_v$=**departure SOC of vehicle**
$SOCmax_v$=**maximum SOC of the vehicle**
$SOCmin_v$=**minimum SOC of the vehicle**
v=**vehicle**
t=**tariff rate**
γ_{ch}=**charging rate**
γ_{dch}=**discharging rate**
$u_{v,t}$=**decision variable (1/0),i.e.,scheduled for charging/discharging or hold.**

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Chapter 1

Introduction

1.1 General

-In future,due to the shortages of the resources,the use of necessary fuels like petrol will certainly have to be controlled .Therefore,facilities like Plug-in hybrid vehicles could offer great range to manage such needs.So, more entrance of such PHEVs will deal with these necessities alongside enhancing productivity and dealing with the nursery gasses and fossil fuel shortages.Hyundai arrangements to dispatch its half breed auto Ioniq by 2017.The auto comes in three versions:hybrid,plug-in mixture and electric.To advance eco-accommodating vehicles,the government propelled FAME India plot which offers motivating forces.

1.2 Important Terms[1]

-HEV= gas + battery, PHEV= fuel + battery + electric charge, BEV = battery + electric charge, EREV = gas + generator + electric charge +battery SOC-It is the condition of charge. It is what might as well be called a fuel gage for the battery pack in a BEV,HV or PHEV. Its unit is percentage or kW per hour.

1.3 Batteries for PHEV[1]

-Vitality stockpiling frameworks, for the most part batteries are basic for HEVs, PHEVs and all EVs.

- **Lithium-Ion batteries**
- **Nickel-Metal Hydride batteries**
- **Lead-Acid batteries**

- **Ultra capacitors**

A power module resembles a battery in that it produces control from an electrochemical reaction. Both batteries and power gadgets change over manufactured essentialness into electrical imperativeness moreover, as a by-aftereffect of this strategy, into warmth. Regardless, a battery holds a close store of essentialness inside it and once this is depleted the battery must be discarded, or empowered by using an external supply of energy to drive the electrochemical reaction in the pivot course. A vitality part, on the other hand, can run uncertainly the length of it is furnished with a wellspring of hydrogen fuel (thus the name) and resembles an ICE in that it oxidizes fuel to make essentialness; yet as opposed to using smoldering, a power module oxidizes hydrogen electrochemically in an incredibly proficient way. In the midst of the reaction, hydrogen particles respond with oxygen iotas to casing water; in the process electrons are released. Besides, through an external circuit as an electric current. The primary exhaust is water vapor.

Li-molecule batteries have high vitality to weight extent, high essentialness effectiveness, and low self-discharge. An expansive segment of its parts can be reused. Most vehicles(electric) use Li-molecule batteries. Investigate Development is proceeding to decrease and intensify their important life.

Nickel-metal hydride batteries have been successfully used as a part of each and every electric vehicle additionally, extensively in PHEVs. Regardless, they have high cost, high self discharge and warmth time at high temperatures and need to control hydrogen mishap.

Lead-corrosive batteries are cheap, protected and dependable. In any case, low specific vitality,poor chilly temperature execution and short calender and cycle life obstruct their utility.

Ultra capacitors store imperativeness in empowered liquid between a cathode and an electrolyte. Essentialness stockpiling limit augments as liquids surface district increases.

Two things are required for the market presentation of FCEV: the autos themselves and hydrogen refueling stations to bolster them. In any market, a base number of each is important to bolster interest for the other.

Nissan is anticipating that following 10 years, when supplanted, the Li-particle vehicle batteries will in any case have the capacity to acknowledge 80 percent of the first battery capacity.Sold on as a certified stationery battery packs, they will in any case have valuable life.

Utilizing EVs with bidirectional power ow capacities to move stack from crest to o-pinnacle is called crest shaving.

This is win-win circumstance for utility and EV proprietors. By and by, pinnacle shaving or stack moving is a thin edge business. Note that capacity gives limit and not vitality to utility framework. In utility purviews where there is a showcase for auxiliary administrations, the remuneration is much higher than that gave for load moving.

1.4 Charging levels for PHEV[1]

-

- Level 1-120V AC-Typical evaluations for these repositories are 15 or 20 amps. This is an essential part of foundation on account of across the board accessibility.Along these lines, organizations that give vehicle changes to electric and future EV and PHEV providers will probably give level 1 line set. With rating of 15 amps, real present attracted is restricted to 12 amps drawing 1.4 kW control.

- Level 2-240V AC-This is portrayed as essential and favored strategy for EVSE both for private and open offices and specifies 240V AC. It permits present as high as 80 amps AC. This level of charge gives higher voltage that permits much quicker battery charge rebuilding. It gives larger amount of well being. The vehicle charger will speak with EVSE to distinguish circuit rating and change charge to battery in like manner.

- Level 3-Charging-This is the quick charging for business and open applications and is planned to perform like a gas benefit station in that charge return is fast. The vehicles on board battery administration framework controls on-board charger to convey DC specifically to battery.

For the buy of PHEV, the aggregate cost of proprietorship must be considered. Cost Of Ownership is a monetary survey anticipated that would help buyers and proprietors thwart mine the quick, underhanded costs of thing or structure. It is an organization thought used as a piece of full cost accounting or even characteristic budgetary viewpoints where it joins social expenses.

The buy of PHEV has expanded from the last numerous years.

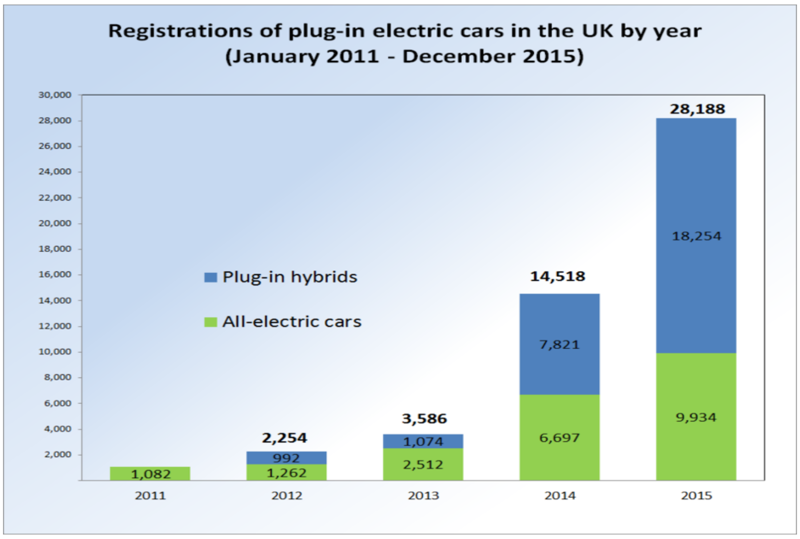


Figure 1.1: UK statistics[1]
Figure shows the rise of electric cars in UK.

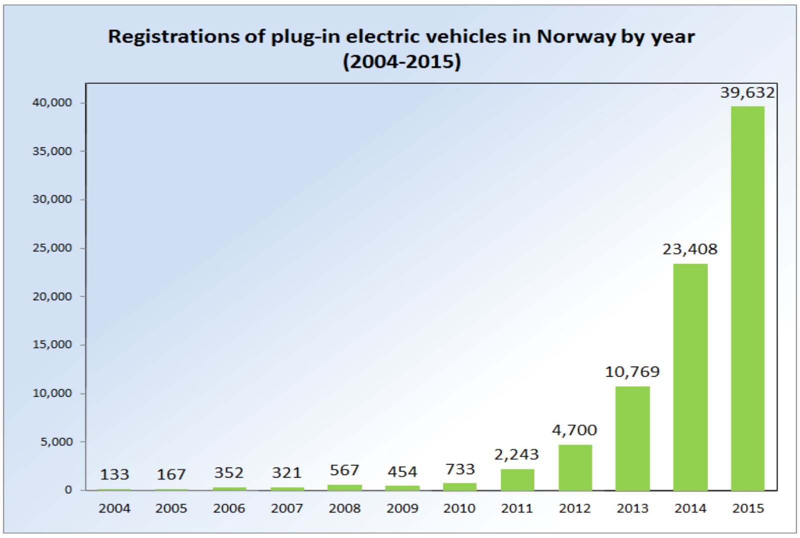


Figure 1.2: Norway statistics[1]
Figure shows the electric vehicle growth in Norway.

Figure 1.3: Chevrolet Volt[1]
Chevrolet Volt is the most preferred electric car across US.

Figure 1.4: Parking Lot for Plug in electric vehicles[1]
Figure shows the parking lot for charging the PHEV vehicles.

Chapter 2

Literature Survey

(1)Mohsen Mazidi; Ali Abbaspour et-al, "Optimal allocation of PHEV parking lots to minimize distribution system losses",*International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering Vol:9, No:8, 2015.*

-In this paper, an improvement based approach is proposed to decide the ideal PHEV stopping limits in hopeful hubs of the appropriation framework. In this manner, a profile for charging and releasing of PHEVs is created keeping in mind the end goal to level the system stack profile. At that point, this profile is utilized as a part of tackling a streamlining issue to minimize the conveyance framework losses.In this, a charging profile for PHEV is created, the quantity of houses are computed and the heap profile is minimized.Brought together administration and control of charging procedure of PHEVs can minimize misfortunes in the influence framework and straighten organize stack profile.

(2)Ehsan Heydarian-Forushani et-al,"Flexible interaction of plug-in electric vehicle parking lots for efficient wind integration", *Department of Electrical and Computer Engineering, Isfahan University of Technology, Isfahan:www.elsevier.com/locate/apenergy.*

Here, a two-organize stochastic system compelled UC detailing with the point of giving extra flexibility to bolster wind joining considering the ability of ordinary supply-side power plants and in addition PLs. Here, instability related to wind speed, starting condition of charge and battery limit of vehicles are considered. The entry time and flight time of vehicles at parking garage is considered.SOE,limits are measured.
Bidirectional connection ability of PEVs presents another adaptable asset into today's traditional power frameworks

(3)Nilufar Neyestani et-al,"Comparison of Various Operational Statuses

of PIEV Aggregators with Home-Charged EVs and Parking Lots", *in Proceedings of the IEEE international Conference on PES,27-31 July 2014.*

Module electric vehicles interest in the power market is the vital issue in the new environment. Here, two conditions of force framework for the benefit of home-charged PIEVs and parking areas are examined. PIEV principle commitment is the market infiltration. In this way, new assets must be created for this. Accordingly, aggregators have come up. In house battery charging and battery charging in parking garage are thought about. Both the techniques are utilized together and it is called facilitated strategy. Contract is chosen for the base SOC. .
This paper expected to make an examination between two situations where singular aggregators controls home-charging PIEVs and those stopped at PLs with the circumstance where one facilitated aggregator controls the entire framework.

(4)Mahnaz Moradijoz et-al,"Optimum Allocation of Parking Lots in Distribution Systems for Loss Reduction",*in Proceedings of the IEEE conference on Power and Energy Society,22-26 July 2012.*

The batteries of PHEVs can go about as capacity and can go about as member in power markets. Here, V2G control gave by ideal distribution of parking garages is concentrated on. PHEVs remain at the parking garages for 93-96 percent time. Along these lines, V2G is a decent idea. In any case, some middle person steps must be taken after. The work of parking garages is to gather the vehicles to store all the vitality of the little limit batteries tom come to a high stockpiling limit. Here, Genetic Algorithm is utilized to ideally designate stopping parcels. For this, weighting components must be chosen. Likewise, the dynamic misfortune list and receptive misfortune record are calculated.It is watched that as the quantity of vehicles in parking area changes, the ideal area for parking garage changes. Any change in charging rate and the quantity of vehicles in parking garage prompt to variety in the ideal area for parking area.
V2G concept is based on the fact that vehicles are parked for about 93-96 percent time during a day. As a result, they are available for other purposes.

(5)Amany El-Zonkoly et-al,"Optimal Allocation, Sizing and Energy Management of PHEV Parking Lots in Distribution System",*Renewable Energy Congress (IREC), 2014 5th International.*

There has been increase in the use of vehicle batteries due to higher penetration of PHEVs. Here, ABC algorithm is used to determine optimal allocation of parking lots. Integration of V2G requires an optimal allocation of parking lots. ABC algorithm uses the behavior of real bees on finding food, and telling other bees about it. There are employed bees, onlooker bees and scout bees.

The target of the proposed calculation is to minimize the general cost of vitality misfortune, vitality transported from the principle matrix, vitality provided by the DGs and the net vitality of charging/releasing the batteries of PHEVs. .

(6)Miadreza Shafie-khah et-al,"Optimal Behavior of Electric Vehicle Parking Lots as Demand Response Aggregation Agents",*IEEE Transactions on Smart Grid (Volume: 7, Issue: 6, Nov. 2016).*

In this paper, another model was proposed to mirror the effects of a few request reaction programs on operational conduct of a PEV parking garage by utilizing a stochastic programing approach. In like manner, both cost based and incentive based projects were concentrated on and interest of the stopping parcel in the request reaction projects was explored considering the instabilities of PEVs' conduct and initiated sum of save by the ISO. In addition, ideal cooperation level of PEV parking area in each DRP was demonstrated that decided how much the PEV parking area ought to have partaken in various DRPs.
The outcomes showed that a parking garage, on the grounds that of its inclination set up of a charging station, carried on like a vast request in the framework and thus support in distinctive request reaction programs fundamentally influenced its operational conduct. Subsequently, the example of charging and releasing of PEVs, the exchanged vitality with the lattice and support in the hold market were seriously impacted by the kind of these request reaction programs. It was watched that some sort of DRPs, for example, TOU could increment the parking area's benefit, however these projects could diminish the advantage of force framework from providing the turning hold by the parking area.
(7)Zahra Darabi et-al,"Plug-in Hybrid Electric Vehicles' Charging Load Profile Extraction Based on Transportation Data",*Power and Energy Society General Meeting, 2011 IEEE.*

This paper portrays strategies to remove valuable data from transportation information. It additionally creates, stack profiles for PHEVs charging in view of different AERs and the 2001 NHTS information. .
In addition, this work applies two potential arrangements to the base sides of the PCLP crystal and creates two diverse PCLPs.
-Plus, the information extricated in this study are sufficiently various and circulated over a sufficiently expansive segment of the nation to allow assurance of likelihood appropriations for the sides that shape the base of the PCLP crystal. At long last, likelihood appropriation of the base sides of the crystal could be utilized as a part of studies identified with stochastic investigations.

(8)Jiayun Zhao et-al,"Integrated analysis of high-penetration PV and PHEV with energy storage and demand response", *Applied Energy, Volume 112, December 2013, Pages 35to51.*

The expanding usage of Plug-in Hybrid Electric Vehicles (PHEVs) in future will have critical affect on service organizations and clients relying upon their charging qualities. Uncontrolled or unscheduled vehicle charging may build the private pinnacle and the danger of electric circulation organize disappointment. To lessen the pinnacle stack service organizations energize clients who have such high power devouring gadgets to partake in different request reaction (DR) programs.
-Additionally,considering expanding Photovoltaic (PV) era and storeroom establishment on client side, the coordination of PHEVs needs more consideration as framework's execution turns out to be exceptionally fluctuating and eccentric. This paper introduces a reenactment based enhancement structure for incorporated examination of interest reaction programs, with high infiltration of PHEV and PV and capacity frameworks from private client's viewpoint and also service organization's point of view.
(9)Chris Huston et-al,"Intelligent Scheduling of Hybrid and Electric Vehicle Storage Capacity in a Parking Lot for Profit Maximization in Grid Power Transactions",*2008 IEEE Energy 2030 Conference Year: 2008 Pages: 1 - 8, DOI: 10.1109/ENERGY.2008.4781051.*
This paper proposes a savvy strategy for planning use of accessible vitality stockpiling limit from module half and half electric vehicles (PHEV) and electric vehicles (EV). The batteries on these vehicles can either give energy to the matrix whenever stopped, known as vehicle-to-framework (V2G) idea or take control from the lattice to charge the batteries on the vehicles. A versatile parking area model is produced with various parameters appointed to armadas of vehicles. The extent of the parking garage is accepted to be sufficiently vast to suit the quantity of vehicles performing framework exchanges. So as to make sense of the fitting charge and release times for the duration of the day, double molecule swarm enhancement is connected.
(10)Mo-Yuen Chow et-al,"Performance evaluation of a PHEV parking station using Particle Swarm Optimization", *Power and Energy Society General Meeting, 2011 IEEE.*
In this paper, a calculation for ideally dealing with countless (i.e., 500) charging at a metropolitan stopping station is proposed.Particle Swarm Optimization (PSO) to cleverly designate vitality to the PHEVs is utilized.The execution portrayal of our PSO calculation utilizing a MATLAB recreation, is contrasted it and different systems.

Chapter 3

Objective and Problem Identification

3.1 Objective

The target work boosts the benefit from working the PLs from the PL administrator's point of view.As the benefit is availed through vitality connections and also singular contracts with PEV proprietors that utilization the parking lots in a V2G state.The cost of vitality collaborations may shift.Also, the rate of charge and discharge are different.The Time Of Use demand response program is studied.

3.2 Problem Identification

The developing charge has expanded the infiltration of module half and half vehicles in the appropriation framework. This should be possible through the establishment of parking lots in the framework.In the event that V2G mode can be used,then Distribution System Operator ought to profit more.The principle reason here is to ideally allot PLs in the conveyance arrange.
-Accordingly, it is expected that new framework specialists, for example, PL proprietors/administrators should be presented.
-Subsequently, the operational arranging of PLs and in addition their allocation ought to be thoroughly broke down.

Chapter 4

Algorithm developed

Table 1 shows the battery capacity of the different PHEV types.

There are 3 charging levels as discussed above.

4.1 Objective function of PSO

$$\sum_{t=1}^{24}(Cin_t - Cout_t)$$

subjected to-

$$Cin_t = \begin{cases} \sum_{v=1}^{V} Pin_{v,t} ift_{arv} < t \leq t_{dep} \\ 0ift > t_{dep,v} ort < t_{arv} \end{cases}$$

$$Cout_t = \begin{cases} \sum_{v=1}^{V} Pout_{v,t} ift_{arv} < t \leq t_{dep,v} \\ 0ift > t_{dep,v} ort < t_{arv} \end{cases}$$

where,

$$Pin_{v,t} = \begin{cases} SOCch_{v,t} \\ \end{cases}$$

$$Pout_{v,t} = \begin{cases} SOCdch_{v,t} \\ \end{cases}$$

Table I: Battery capacity of different PHEVs

PHEV type	Battery capacity
PHEV 1	6.51
PHEV 2	7.21
PHEV 3	8.75
PHEV 4	10.15

4.2 Charge Dynamics

$$SOCch_{v,t} + 1 = SOCch_{v,t} + SOCch_{v,t} * \gamma_{ch}.u$$

$$SOCdch_{v,t} + 1 = SOCdch_{v,t} + SOCdch_{v,t} * \gamma_{ch}.u$$

$$SOC_{max,v} = P_{rat,v} * df_v * Ch_{max,v}$$

$$SOC_{min,v} = SOC_{max,v}(d_v/aer_v)$$

$$SOC_{in,v} = SOC_{max,v} * (1 - (d_v/aer_v))$$

$$SOC_{dep,v} \geq SOC_{min,v}$$

Chapter 5

Case Study

A survey of a parking lot has been conducted to study the nature of a public parking lot. The number of vehicles arriving,departing and their total miles travelled are studied.The derating factor also plays an important role in it.

Table I: Vehicle Data

Battery rating	Distance	AER	Derating factor	Arrival time	Departure time	Charging effic
6.51	3	16	0.955	8	17	0.86
7.21	4	16	0.946	8	17	0.86
6.51	6	16	0.944	9	18	0.86
8.75	7	16	0.941	10	18	0.86
7.21	6	16	0.925	10	18	0.86
6.51	13	16	0.955	10	18	0.86
7.21	11	16	0.962	10	19	0.86
8.75	31	32	0.892	10	19	0.81
6.51	13	32	0.902	10	18	0.81
7.21	13	16	0.931	10	18	0.86
6.51	10	32	0.92	10	18	0.81
7.21	2	16	0.872	10	19	0.86
8.75	5	16	0.925	10	18	0.86
6.51	2	16	0.927	11	18	0.86
10.15	3	16	0.947	11	18	0.86
7.21	4	32	0.969	11	19	0.81
6.51	3	16	0.964	11	18	0.81
8.75	2	16	0.956	11	18	0.81
6.51	6	16	0.973	11	19	0.81
10.15	4	16	0.881	11	20	0.81

All vehicles have Li-ion battery.
Total number of kms covered in the battery lifetime are also considered to know the aging factor.

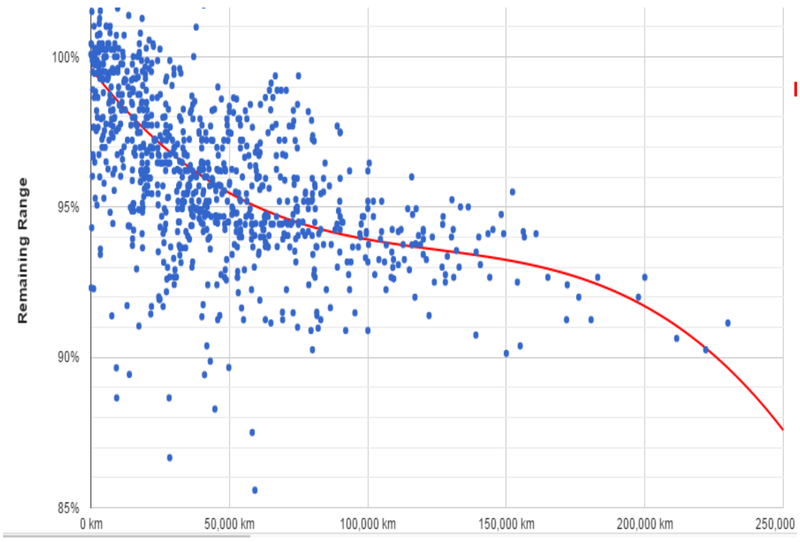


Figure 5.1: Deciding Battery Derating

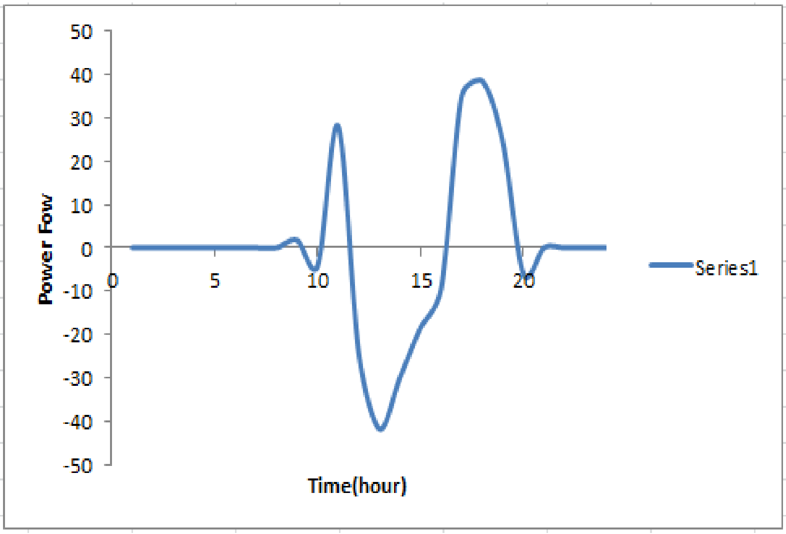


Figure 5.2: Power Flow

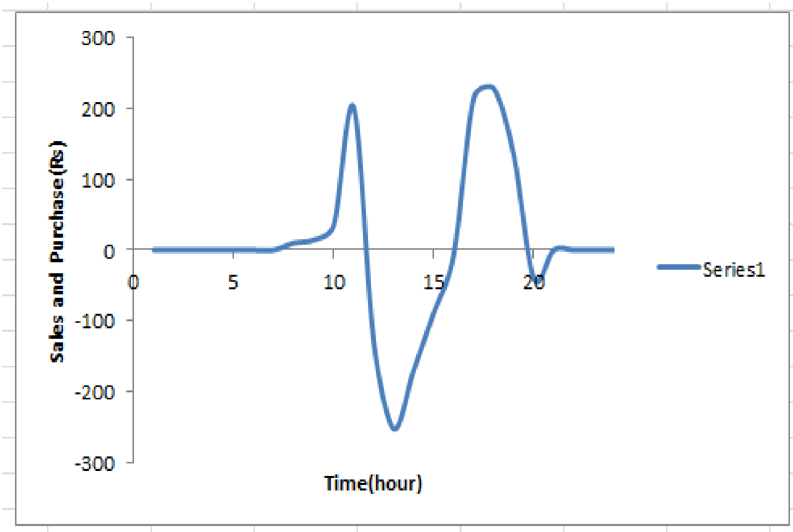


Figure 5.3: Purchase and Sale

Chapter 6

Time Of Use

Time Of Use is a demand response program. A TOU rate is a power rate structure where the cost of power differs with time of day. TOU rates are for the most part outlined to speak to the way that power is more costly to create and convey when the network is exceptionally stacked and less costly to create and convey when the lattice is delicately stacked. TOU rates boost the preservation of power amid periods of appeal and high conveyance cost, along these lines augmenting financial proficiency. PHEV are anticipated to be to a greater extent a mass-showcase vehicle than EV, the effect of PHEV on the electric matrix could be bigger than the effect of EV. Investigations of PHEV financial and natural effects have accepted that PHEV charging conduct can be controlled by incenting off-pinnacle charging through TOU rates.Then,the Time of Use data is given based on the peak times and off-peak times.

In India, Time of Day (TOD) duty that was utilized for the most part for modern segment is currently gradually being presented for business segment too. Late news articles in a portion of the main daily papers in India recommend that utilities are examining executing time of day tax for business clients (alongside the mechanical clients in State where it has not been presented up until now). A few states have effectively executed it and others are arranging. Furthermore, as the interest for power is expanding each day, the day is not far when the private clients may likewise observe the same. So in the event that you have an office or possess a private company, this adjustment in tax can unquestionably affect your power charge. It might display an opportunity to you to lessen your bill by modifying the way you devour power in your office. Time of Day (or TOD) levy is a duty structure in which diverse rates are pertinent for utilization of power at various time. It implies that cost of utilizing 1 unit of power will be diverse in mornings, twelve, nighttimes and evenings. This implies utilizing machines amid certain time will be less expensive than utilizing them amid different circumstances.

Power lattices can be contrasted with street or thruway that can suit just a specific number of vehicles at any given moment. Amid pinnacle hours interstates are stuck, also amid pinnacle hours, power networks are stuck. Drive on interstate amid off pinnacle hours resembles a breeze, likewise stream of power amid off pinnacle hours is a breeze. Imagine a scenario in which individuals are charged distinctively to use parkways amid various circumstances and furthermore charged according to size of their vehicles. Individuals with either like to experience parkway when activity is less (off pinnacle) or might want to utilize a bike. Similaly, with TOD levy, individuals will either change to a period when costs are less or will begin utilizing productive apparatuses (with lesser power utilization).

Power utilization is expanding definitely and the creation is not growing up at that pace. Lack of fuel (coal) adds to the issue. To ensure that there is adequate supply for the request, utilities need to ensure that they help their clients deal with their energy utilization. It is not that they lessen their benefits by helping clients diminishing utilization, however they do this to ensure that they can supply power to all clients according to their requests. Issue that utilities face is of pinnacle power request. There are sure circumstances in the day when the interest for power is at its pinnacle. Amid these circumstances, utilities need to buy control at high cost, considerably higher than the cost paid by customers. To decrease the pinnacle control requests there are two choices: Either they diminish the power request at the pinnacle hours or general lessening in power request. Here,comparison of several fixed and Time of Use tarriffs have been done.

Table I: Different tarriff rates

Fixed-3	Fixed-4	Fixed-5	Fixed-6	ToU-1	ToU-2	ToU-3	ToU-4	ToU-5
3	4	5	6	5	4	5	6	7
3	4	5	6	5	4	5	6	7
3	4	5	6	5	4	5	6	7
3	4	5	6	5	4	5	6	7
3	4	5	6	5	6	7	8	9
3	4	5	6	3	2	3	4	5
3	4	5	6	3	2	3	4	5
3	4	5	6	3	2	3	4	5
3	4	5	6	3	2	3	4	5
3	4	5	6	5	4	5	6	7
3	4	5	6	5	4	5	6	7
3	4	5	6	7	6	7	8	9
3	4	5	6	7	6	7	8	9
3	4	5	6	7	6	7	8	9
3	4	5	6	7	6	7	8	9
3	4	5	6	5	4	5	6	7
3	4	5	6	5	4	5	6	7
3	4	5	6	5	4	5	6	7
3	4	5	6	5	4	5	6	7
3	4	5	6	7	6	7	8	9
3	4	5	6	7	6	7	8	9
3	4	5	6	7	6	7	8	9
3	4	5	6	7	6	7	8	9
3	4	5	6	7	6	7	8	9

Chapter 7

Particle Swarm Optimization

PSO is an iterative stochastic streamlining calculation in view of the development patters of groups of flying creatures or schools of fish.A set or populace of potential arrangements is known as a swarm.These potential arrangements are alluded to as particles and each one looks for the arrangement with a level of autonomy from each other. In every emphasis, the particles utilize their past best arrangement and additionally the swarm's best arrangement.Along these lines, the particles are guided on the whole toward better furthermore, better arrangements.Particle swarm Optimization (PSO) is a populace based stochastic advancement method created by Dr. Eberhart and Dr. Kennedy in 1995, motivated by social conduct of fowl running or fish tutoring. PSO offers numerous similarities with transformative calculation strategies, for example, Genetic Algorithms (GA).The decision of PSO parameters can largy affect advancement execution. Choosing PSO parameters that yield great execution has accordingly been the subject of much research.The PSO parameters can likewise be tuned by utilizing another overlaying analyzer, an idea known as meta-enhancement, or even tweaked amid the improvement, e.g., by methods for fuzzy logic.Parameters have additionally been tuned for different streamlining situations.

The topology of the swarm characterizes the subset of particles with which every molecule can trade data. The essential variant of the calculation utilizes the world-wide topology as the swarm correspondence structure. This topology enables all particles to speak with the various particles, along these lines the entire swarm have a similar best position g from a solitary molecule. In any case, this approach may lead the swarm to be caught into a nearby least, along these lines diverse topologies have been utilized to control the stream of data among particles. For example, in nearby topologies, particles just impart data to a subset of particles.This subset can be a geometrical one for instance "the m closest particles" or, all the more frequently, a social one, i.e. an arrangement of particles that is not relying upon any separation. In such cases, the PSO variation is said to be neighborhood best.As the fundamental PSO works measurement by measurement, the arrangement point is less demanding found when it lies on a pivot of the pursuit space, on an askew, and much simpler on the off chance that it is spot on the middle. Various variations of even a fundamental PSO calculation are conceivable. For instance, there are distinctive approaches to instate the particles and speeds (e.g. begin with zero speeds rather), how to hose the speed, just refresh pi and g after the whole swarm has been refreshed, and so forth. Some of these decisions and their conceivable execution affect have been talked about in the writing.

Steps: 1. Instate a populace of particles, each speaking to a conceivable arrangement, by appointing arbitrary arrangements inside the given arrangement space to the issue's factors. 2. Assess wellness work appointed to the issue. In this application condition (7) is utilized with better arrangements having a higher outcome when the wellness capacity is assessed. 3. For every molecule, look at the wellness at the currentcycle with the molecule's best past wellness. The best past answer for a molecule is known as its individual best or Pbest arrangement. 4. Select the best arrangement of all the Pbest answers for be the worldwide best or Gbest arrangement. 5. Refresh of each molecule speed , what's more, position utilizing. 6. Rehash steps 2-5 until a worldwide arrangement is found inside a predefined number of cycles.

7.1 Objective of the PSO

The main purpose of the particle swarm process is to reduce/optimize the cost. The cost,here refers to the discharging cost subtracted from the charging cost. Optimization of the cost is beneficial to the customer. The customer can participate in the charging scenario if the cost is less and the revenue he gets is more.

7.2 The particle formulation

The particle swarm consists of SOC for given vehicle for time instant 't'. The particles are binary in nature,have binary part,1 and 0 is used. Swarm particles represent binary status for deciding charging,discharging/hold decision,1 for charging and 0 for hold.

$$v_{ij}(itr) = w*v_{ij}(itr-1)+c_1*rand_1*(P_{best}(itr)-X_{ij}(itr-1))+c_2*rand_2*(G_{best}(itr)-X_{ij}(itr-1))$$

$$v_{ij}'(itr) = sig(v_{ij}(itr)) = 1/1 + e^{-v_{ij}(k)}$$

$$X_{ij}(itr) = \begin{cases} 1 if rand < v_{ij}'(itr) \\ 0 otherwise \end{cases}$$

7.3 Constraints in the PSO

Constraints are the maximum limits upto which things can be done.Here,the maximum limits are at the energy to be injected.So, the constraints here are:- Maximum SOC, Minimum SOC

Chapter 8

Results

8.1 Charging and Discharging schedules

Table I: Fixed tariff 3

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	dchg	dchg	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	chg	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	dchg	dchg	chg	chg	chg	dchg	0	0	dchg	dchg	0
12	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	dchg	hold	chg	dch
13	0	0	0	0	hold	hold	hold	hold	hold	0	hold	hold	0	hol
14	dchg	dchg	chg	hold	dchg	hold	hold	chg	dchg	chg	hold	hold	dchg	dch
15	dchg	dchg	hold	hold	hold	chg	hold	chg	hold	chg	hold	dchg	0	hol
16	dchg	dchg	hold	hold	hold	chg	chg	chg	hold	chg	hold	hold	0	dch
17	0	0	0	0	hold	0	hold	hold	0	0	hold	hold	0	hol
18	0	0	hold	0	hold	0	hold	chg	hold	chg	hold	hold	dchg	dch
19	0	0	0	0	0	0	chg	0	0	0	0	hold	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table II: Fixed tariff 3

Hour	15	16	17	18	19	20
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	00
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	dchg	0	0	0	0
13	0	0	0	0	0	0
14	dchg	dchg	dchg	dchg	0	0
15	dchg	dchg	dchg	dchg	dchg	0
16	hold	dchg	hold	dchg	hold	dchg
17	hold	0	hold	hold	0	hold
18	dchg	0	dchg	dchg	0	dchg
19	0	0	0	0	0	hold
20	0	0	0	0	0	hold
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0		0	0

Table III: Fixed tariff 4

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	1
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	dchg	0	0	0	0	0	0	0	0	0	0	0	0
10	0	hold	dchg	0	0	chg	0	0	0	0	0	0	0	0
11	dchg	dchg	chg	chg	chg	hold	0	chg	chg	chg	chg	0	chg	0
12	hold	hold	hold	hold	hold	hold	0	hold	hold	hold	hold	0	hold	c
13	dchg	dchg	dchg	dchg	dchg	chg	chg	chg	hold	chg	dchg	0	dchg	c
14	hold	hold	hold	hold	hold	hold	hold	hold	hold	hold	hold	0	hold	c
15	dchg	hold	hold	hold	hold	chg	hold	chg	dchg	chg	dchg	dchg	dchg	c
16	hold	hold	hold	hold	hold	hold	hold	chg	hold	hold	hold	hold	hold	h
17	hold	hold	hold	0	hold	hold	hold	hold	hold	holod	hold	hold	hold	h
18	0	0	hold	0	dchg	chg	chg	chg	dchg	chg	dchg	dchg	dchg	c
19	0	0	0	0	0	0	chg	chg	0	0	0	dchg	hold	0
20	0	0	0	0	0	0	0	0	0	0	0	hold	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table IV: Fixed tariff 4

Hour	15	16	17	18	19	20
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	00
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	dchg	chg	chg	dchg	0	0
13	dchg	dchg	dchg	chg	0	dchg
14	hold	hold	dchg	hold	0	0
15	hold	dchg	dchg	dchg	dchg	hold
16	hold	hold	hold	hold	hold	hold
17	hold	hold	hold	hold	hold	hold
18	dchg	dchg	dchg	dchg	dchg	dchg
19	0	dchg	dchg	hold	0	hold
20	0	0	0	0	0	hold
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0		0	0

Table V: Fixed tariff 5

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	dchg	dchg	0	0	0	0	0	0	0	0	0	0	0	0
10	hold	hold	dchg	0	0	0	0	0	0	0	0	0	0	0
11	chg	chg	chg	chg	chg	0	0	hold	chg	0	chg	dchg	dchg	0
12	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	ch
13	dchg	dchg	dchg	dchg	dchg	chg	hold	chg	hold	hold	dchg	dchg	hold	dc
14	hold	hold	hold	hold	hold	hold	hold	hold	hold	hold	hold	hold	hold	ho
15	dchg	dchg	dchg	dchg	hold	0	chg	chg	dchg	chg	dchg	dchg	hold	dc
16	dchg	dchg	hold	hold	dchg	chg	hold	chg	dchg	chg	dchg	dchg	dchg	dc
17	dchg	dchg	hold	0	dchg	chg	chg	chg	dchg	chg	dchg	dchg	hold	dc
18	0	0	hold	0	hold	hold	hold	hold	hold	hold	0	0	hold	ho
19	0	0	0	0	0	0	hold	chg	0	0	0	0	hold	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table VI: Fixed tariff 5

Hour	15	16	17	18	19	20
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	dchg	chg	chg	0	chg	0
13	dchg	dchg	dchg	chg	0	0
14	hold	hold	hold	hold	0	0
15	hold	dchg	dchg	dchg	dchg	hold
16	dchg	dchg	dchg	dchg	hold	dchg
17	hold	dchg	dchg	dchg	dchg	hold
18	hold	hold	hold	hold	hold	hold
19	0	dchg	hold	hold	dchg	dchg
20	0	0	0	0	0	hold
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0		0	0

Table VII: Fixed tariff 6

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	dchg	dchg	0	0	0	0	0	0	0	0	0	0	0	0
10	hold	hold	0	0	0	0	0	0	0	0	0	0	0	0
11	chg	hold	0	dchg	dchg	0	0	chg	0	chg	dchg	0	dchg	0
12	chg	chg	chg	chg	chg	chg	0	chg	chg	hold	chg	chg	chg	ch
13	chg	chg	chg	chg	chg	hold	hold	chg	chg	hold	chg	chg	chg	ch
14	dchg	dchg	dchg	hold	hold	chg	chg	chg	dchg	chg	dchg	dchg	dchg	dc
15	dchg	dchg	dchg	dchg	dchg	chg	chg	chg	dchg	chg	dchg	dchg	dchg	dc
16	hold	hold	hold	hold	hold	hold	hold	hold	hold	hold	dchg	hold	hold	ho
17	hold	hold	hold	0	hold	hold	hold	hold	dchg	hold	dchg	hold	hold	ho
18	0	0	dchg	0	dchg	chg	chg	chg	dchg	chg	hold	dchg	dchg	dc
19	0	0	0	0	0	0	hold	chg	0	0	dchg	0	hold	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table VIII: Fixed tariff 6

Hour	15	16	17	18	19	20
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	dchg	chg	chg	0	chg	chg
13	chg	chg	chg	chg	chg	chg
14	dchg	dchg	dchg	dchg	0	dchg
15	dchg	dchg	dchg	dchg	hold	dchg
16	hold	hold	hold	hold	hold	hold
17	dchg	hold	hold	hold	hold	hold
18	hold	dchg	dchg	dchg	dchg	dchg
19	0	dchg	hold	hold	dchg	dchg
20	0	0	0	0	0	hold
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0		0	0

Table IX: ToU tariff 1

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	dchg	dchg	0	0	0	0	0	0	0	0	0	0	0	0
10	hold	hold	dchg	0	0	0	0	0	0	0	0	0	0	0
11	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	ch
12	dchg	dchg	dchg	hold	hold	hold	hold	hold	hold	hold	dchg	dchg	dchg	dc
13	hold	hold	hold	hold	hold	hold	hold	hold	hold	hold	hold	dchg	hold	ho
14	dchg	dchg	hold	hold	dchg	hold	hold	hold	hold	hold	dchg	dchg	dchg	dc
15	dchg	dchg	hold	dchg	dchg	hold	hold	hold	hold	hold	hold	hold	dchg	dc
16	hold	hold	hold	hold	hold	chg	hold	chg	hold	hold	hold	hold	hold	ho
17	hold	hold	hold	0	hold	chg	chg	chg	dchg	chg	hold	hold	hold	ho
18	0	0	hold	0	hold	chg	chg	chg	dchg	chg	hold	hold	hold	ho
19	0	0	0	0	0	0	hold	chg	0	chg	hold	0	hold	0
20	0	0	0	0	0	0	0	chg	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table X: ToU tariff 1

Hour	15	16	17	18	19	20
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	dchg	dchg	dchg	dchg	hold	0
13	hold	hold	hold	hold	hold	0
14	dchg	dchg	hold	dchg	hold	dchg
15	dchg	dchg	dchg	dchg	hold	dchg
16	hold	hold	hold	hold	hold	hold
17	hold	hold	dchg	dchg	hold	hold
18	hold	hold	hold	hold	hold	hold
19	0	hold	hold	hold	hold	hold
20	0	0	0	0	0	hold
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0		0	0

Table XI: ToU tariff 2

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	chg	chg	0	0	0	0	0	0	0	0	0	0	0	0
10	hold	hold	chg	0	0	0	0	0	0	0	0	0	0	0
11	hold	hold	hold	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	0
12	dchg	dchg	hold	hold	dchg	hold	hold	hold	hold	hold	hold	hold	dchg	ch
13	dchg	dchg	dchg	dchg	dchg	hold	hold	hold	dchg	hold	dchg	dchg	dchg	dc
14	dchg	dchg	dchg	hold	hold	hold	hold	hold	dchg	hold	dchg	dchg	dchg	dc
15	hold	hold	dchg	hold	hold	hold	hold	hold	hold	hold	dchg	dchg	hold	dc
16	hold	hold	hold	hold	hold	chg	chg	chg	hold	chg	hold	hold	hold	ho
17	hold	hold	hold	0	hold	chg	hold	chg	hold	chg	hold	hold	hold	ho
18	0	0	hold	0	hold	chg	chg	chg	hold	chg	hold	hold	hold	ho
19	0	0	0	0	0	0	hold	chg	0	hold	hold	0	hold	0
20	0	0	0	0	0	0	0	chg	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table XII: ToU tariff 2

Hour	15	16	17	18	19	20
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	chg	chg	dchg	chg	0
13	dchg	dchg	dchg	hold	0	0
14	dchg	dchg	dchg	dchg	dchg	0
15	dchg	dchg	dchg	dchg	dchg	dchg
16	hold	hold	hold	hold	hold	hold
17	hold	hold	hold		hold	hold
18	hold	hold	hold	hold	hold	hold
19	0	hold	hold	hold	hold	hold
20	0	0	0	0	0	dchg
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0		0	0

Table XIII: ToU tariff 3

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	hold	0
12	dchg	dchg	hold	dchg	dchg	dchg	hold	hold	hold	hold	dchg	dchg	hold	dc
13	dchg	dchg	hold	dchg	dchg	dchg	hold	hold	dchg	hold	dchg	hold	dchg	dc
14	hold	hold	dchg	hold	hold	hold	hold	hold	dchg	hold	hold	hold	hold	dc
15	hold	hold	dchg	hold	hold	hold	hold	hold	hold	hold	hold	dchg	dchg	dc
16	chg	chg	hold	chg	hold	chg	hold	chg	hold	chg	chg	hold	hold	ho
17	hold	hold	chg	0	chg	chg	chg	chg	hold	chg	hold	chg	hold	ho
18	0	0	hold	0	hold	chg	chg	chg	hold	chg	hold	hold	hold	ho
19	0	0	0	0	0	0	chg	chg	0	hold	hold	0	hold	0
20	0	0	0	0	0	0	0	chg	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table XIV: ToU tariff 3

Hour	15	16	17	18	19	20
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	chg	chg	chg	0
12	0	chg	hold	dchg	chg	0
13	dchg	hold	dchg	dchg	0	0
14	dchg	hold	dchg	hold	hold	dchg
15	dchg	dchg	dchg	hold	dchg	dchg
16	hold	hold	hold	hold	chg	hold
17	hold	chg	chg		hold	hold
18	hold	hold	hold	hold	hold	hold
19	0	hold	hold	hold	hold	hold
20	0	0	0	0	0	0
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0	0	0	0

Table XV: ToU tariff 4

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	chg	chg	0	0	0	0	0	chg	0	0	0	0	0	0
11	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	ch
12	hold	dchg	hold	hold	hold	hold	hold	hold	hold	hold	dchg	hold	hold	ho
13	hold	dchg	dchg	hold	hold	hold	hold	hold	hold	hold	hold	hold	hold	ho
14	hold	dchg	dchg	hold	hold	hold	hold	hold	dchg	hold	dchg	dchg	hold	dc
15	dchg	hold	dchg	hold	hold	hold	hold	hold	dchg	hold	dchg	hold	dchg	ho
16	dchg	hold	hold	chg	hold	chg	hold	chg	hold	chg	hold	hold	hold	ho
17	hold	hold	chg	0	hold	chg	chg	chg	hold	chg	hold	chg	hold	ho
18	0	0	hold	0	hold	chg	hold	chg	hold	chg	hold	hold	hold	ho
19	0	0	0	0	0	0	chg	chg	0	hold	hold	0	hold	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table XVI: ToU tariff 4

Hour	15	16	17	18	19	20
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	chg	chg	chg	chg	chg	chg
12	0	dchg	hold	dchg	hold	hold
13	hold	hold	hold	hold	dchg	0
14	hold	hold	dchg	dchg	hold	hold
15	dchg	dchg	dchg	hold	dchg	dchg
16	hold	hold	hold	hold	chg	hold
17	hold	hold	hold		hold	hold
18	hold	hold	hold	hold	hold	hold
19	0	hold	hold	hold	hold	hold
20	0	0	0	0	0	0
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0	0	0	0

Table XVII: ToU tariff 5

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	chg	0	0	0	0	0	0
10	0	0	0	0	0	0	0	chg	0	0	0	0	0	0
11	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	chg	ch
12	dchg	dchg	dchg	hold	dchg	hold	hold	hold	dchg	hold	dchg	dchg	dchg	dc
13	dchg	dchg	dchg	dchg	hold	hold	hold	hold	dchg	hold	dchg	dchg	hold	dc
14	dchg	dchg	dchg	dchg	dchg	hold	hold	hold	hold	hold	dchg	dchg	hold	dc
15	dchg	dchg	dchg	hold	dchg	hold	hold	hold	dchg	hold	dchg	dchg	dchg	dc
16	0	0	chg	hold	chg	chg	chg	chg	hold	chg	hold	chg	hold	ho
17	0	0	0	chg	hold	chg	chg	chg	chg	chg	chg	chg	hold	ho
18	0	0	hold	0	hold	chg	chg	chg	hold	chg	hold	hold	hold	ho
19	0	0	0	0	0	0	chg	chg	0	hold	hold	0	hold	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table XVIII: ToU tariff 5

Hour	15	16	17	18	19	20
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	chg	chg	chg	chg	chg	0
12	0	dchg	dchg	dchg	hold	dchg
13	dchg	dchg	dchg	dchg	hold	0
14	dchg	dchg	dchg	dchg	dchg	dchg
15	dchg	dchg	dchg	dchg	dchg	dchg
16	hold	hold	chg	hold	chg	hold
17	hold	chg	hold		hold	hold
18	hold	hold	hold	dchg	hold	hold
19	0	hold	hold	hold	hold	hold
20	0	0	0	0	0	0
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0	0	0	0

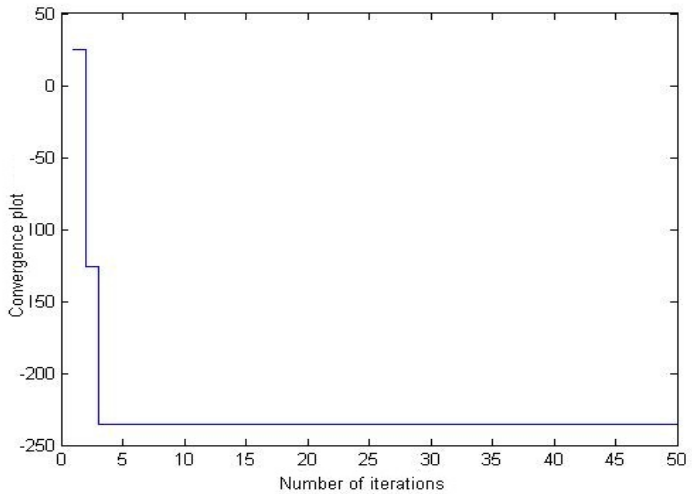


Figure 8.1: Fixed tariff 3

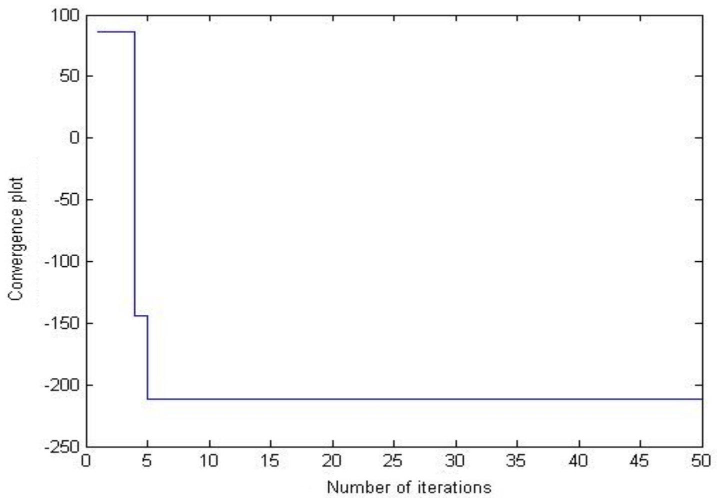


Figure 8.2: Fixed tariff 4

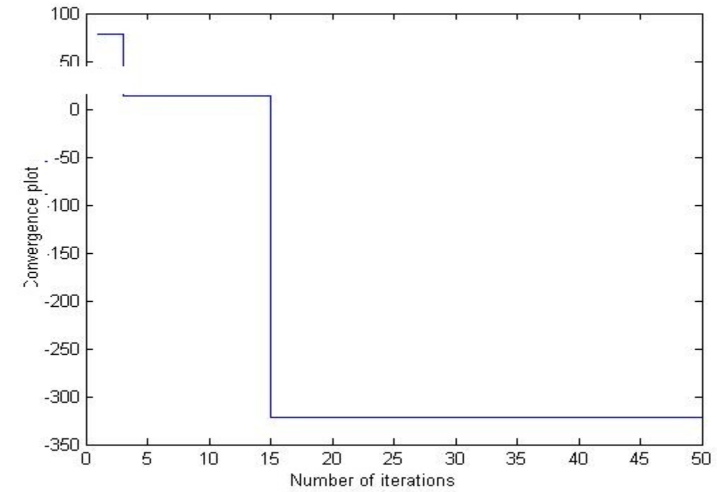


Figure 8.3: Fixed tariff 5

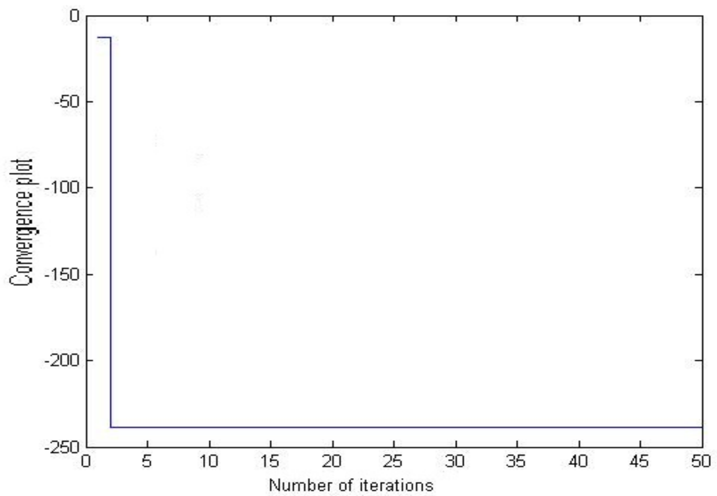


Figure 8.4: Fixed tariff 6

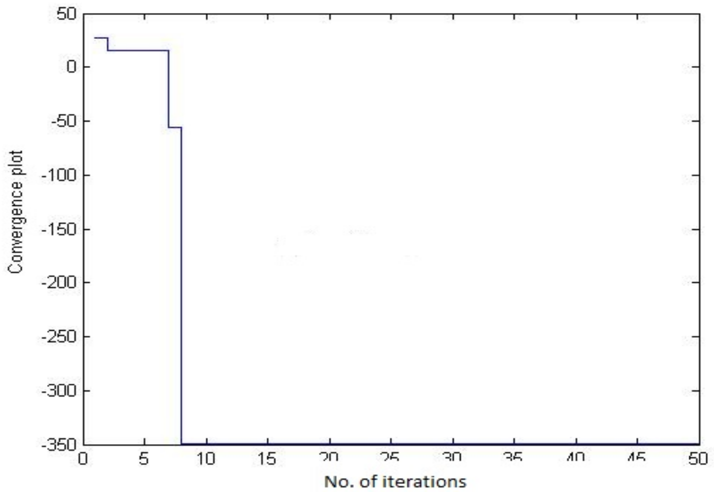


Figure 8.5: ToU tariff 1

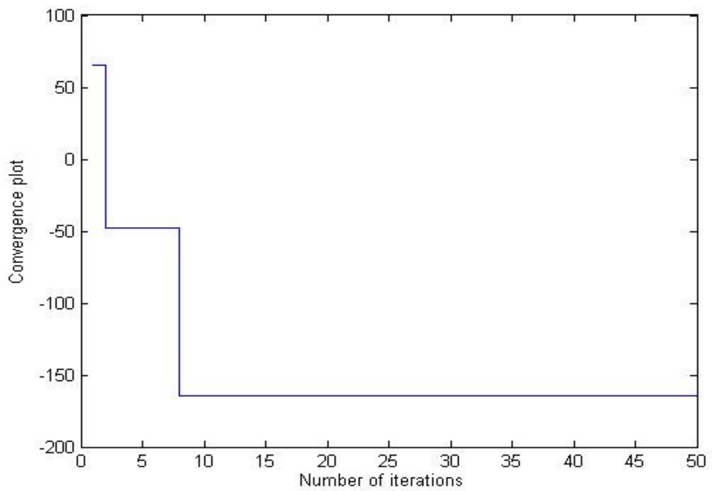


Figure 8.6: ToU tariff 2

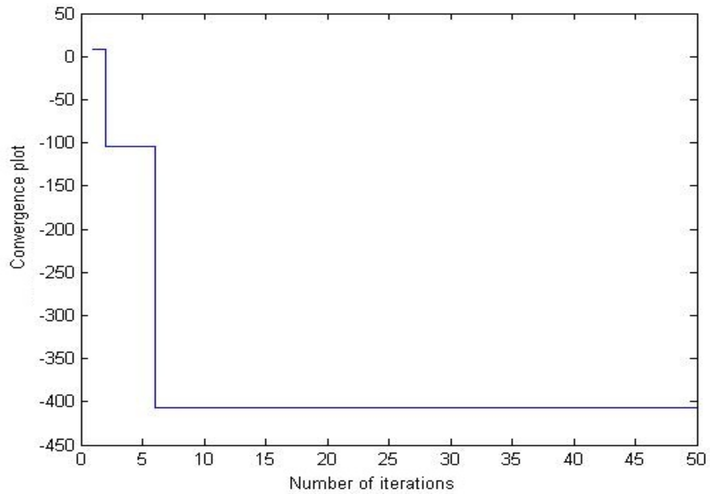


Figure 8.7: ToU tariff 3

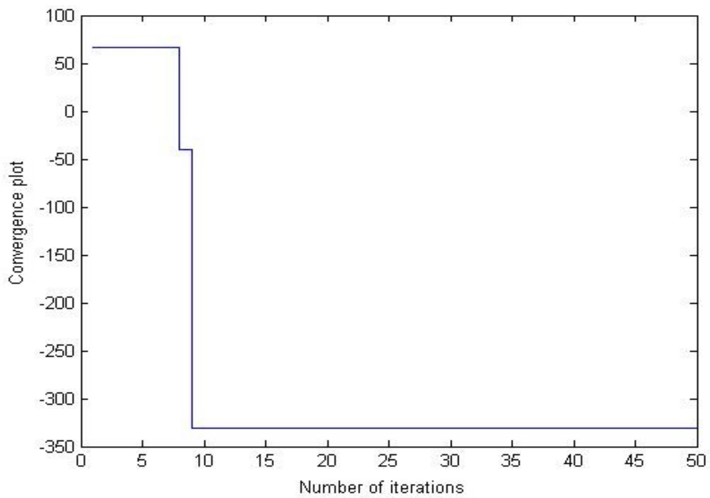


Figure 8.8: ToU tariff 4

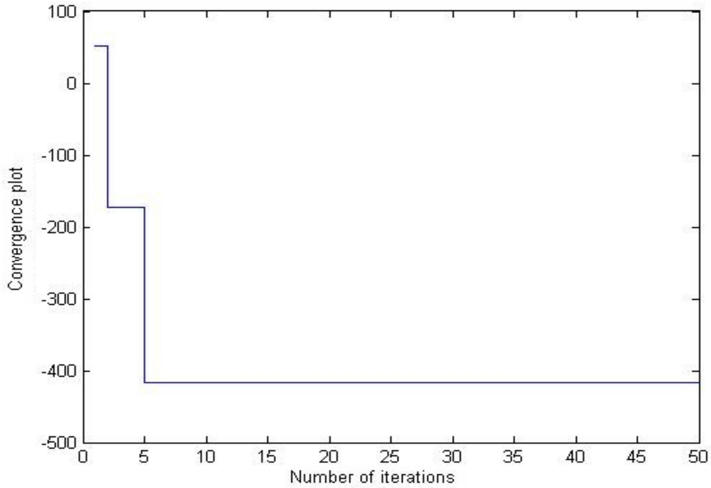


Figure 8.9: ToU tariff 5

8.2 Energy Graphs

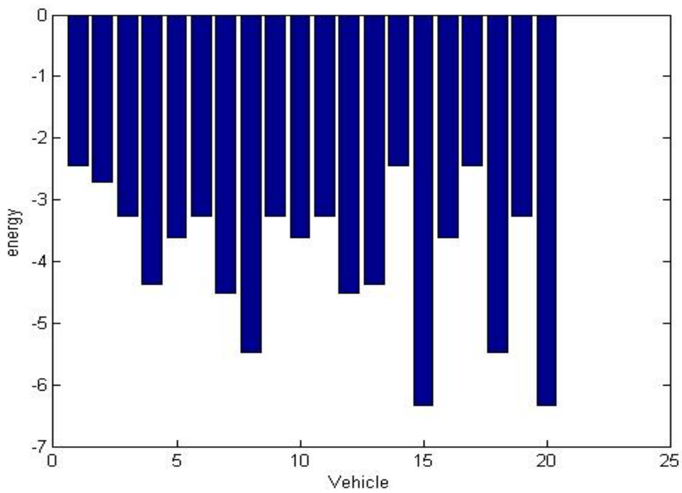


Figure 8.10: Fixed tariff 3

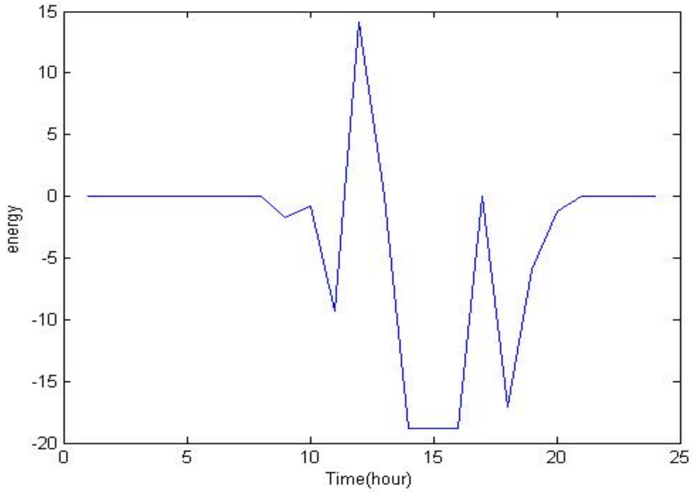


Figure 8.11: Fixed tariff 3

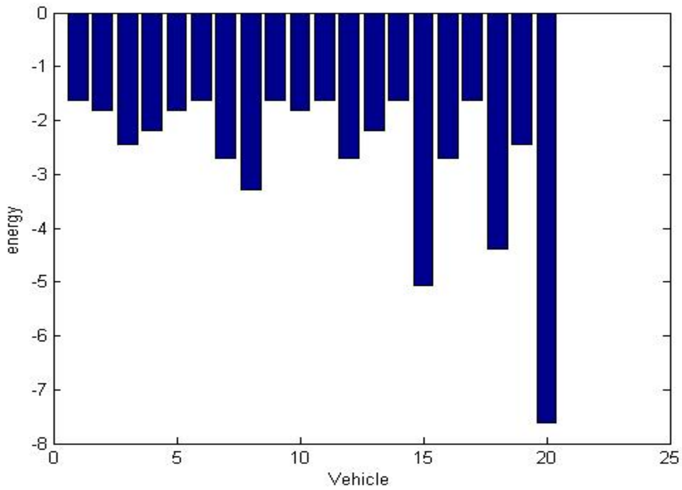


Figure 8.12: Fixed tariff 4

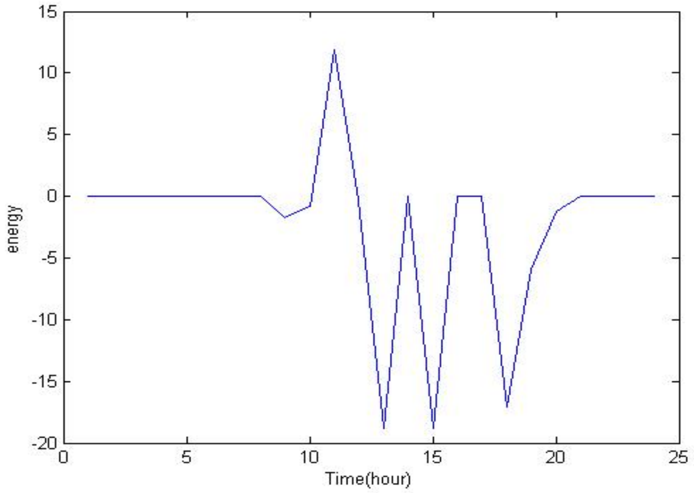


Figure 8.13: Fixed tariff 4

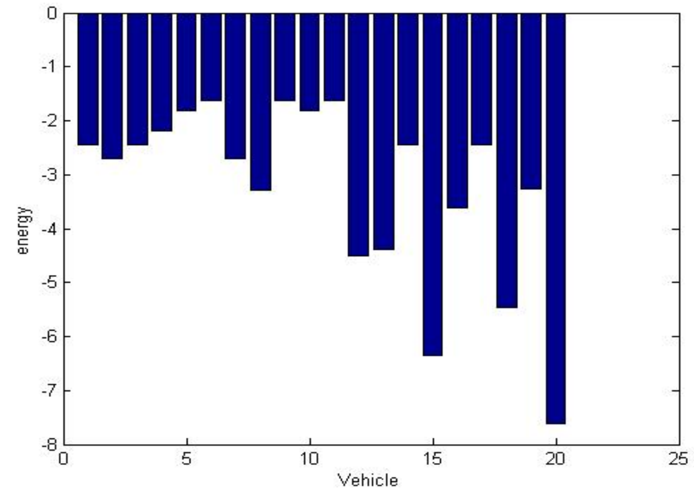


Figure 8.14: Fixed tariff 5

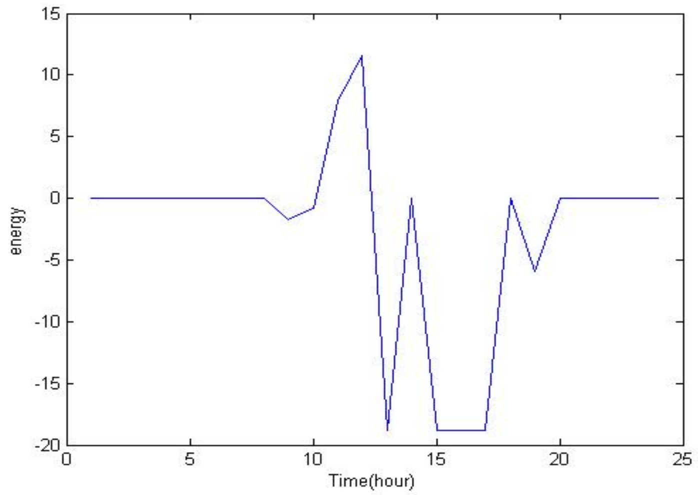


Figure 8.15: Fixed tariff 5

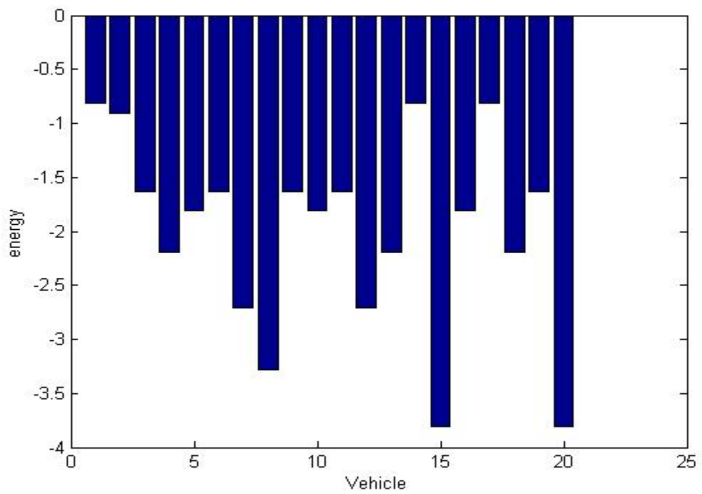


Figure 8.16: Fixed tariff 6

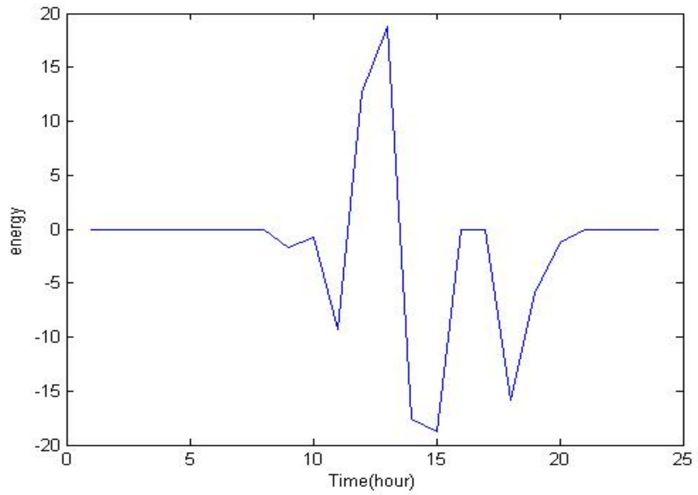


Figure 8.17: Fixed tariff 6

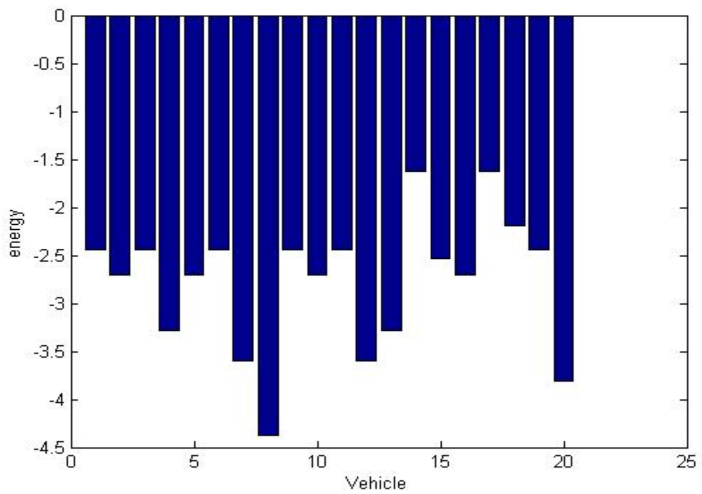


Figure 8.18: ToU tariff 1

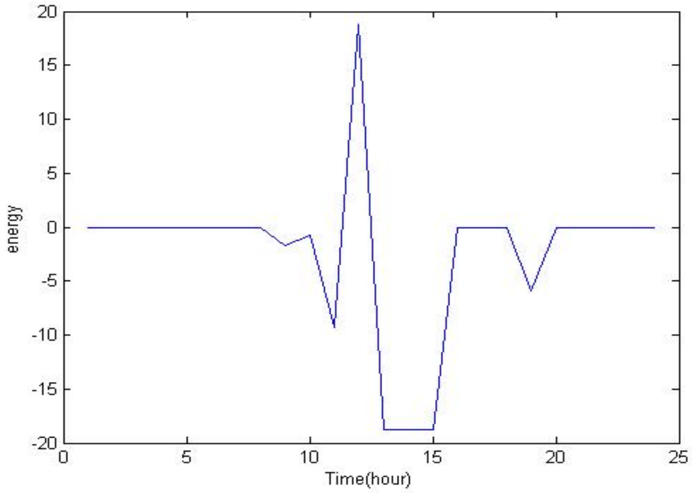
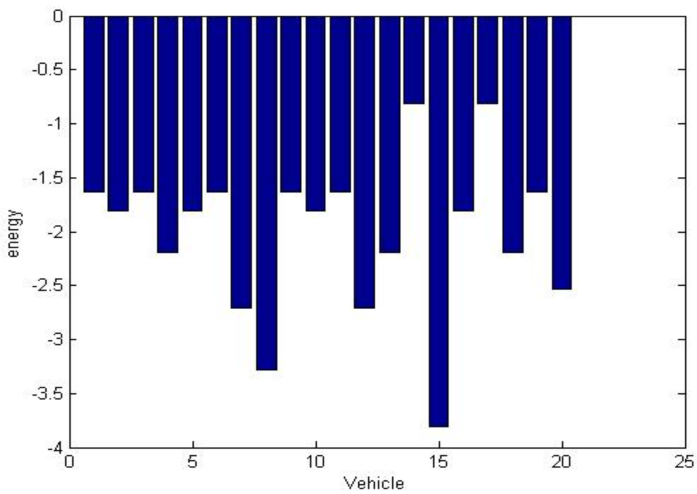


Figure 8.19: ToU tariff 1



![htbp]

Figure 8.20: ToU tariff 2

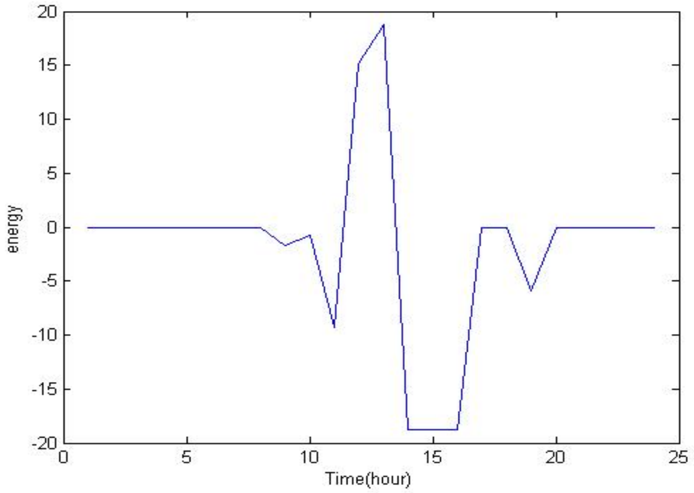


Figure 8.21: ToU tariff 2

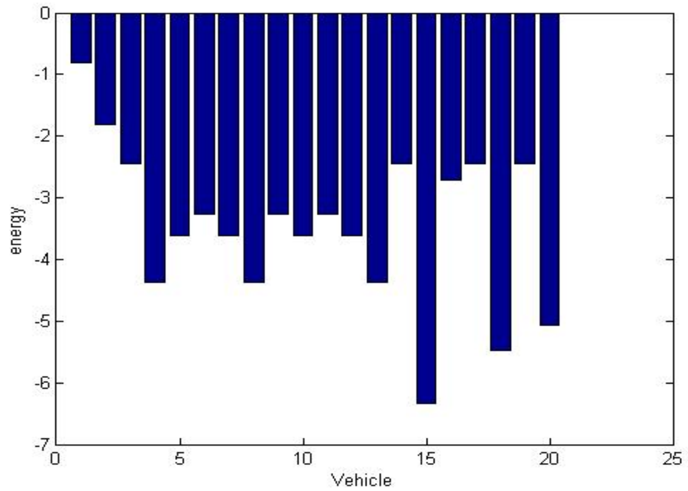


Figure 8.22: ToU tariff 3

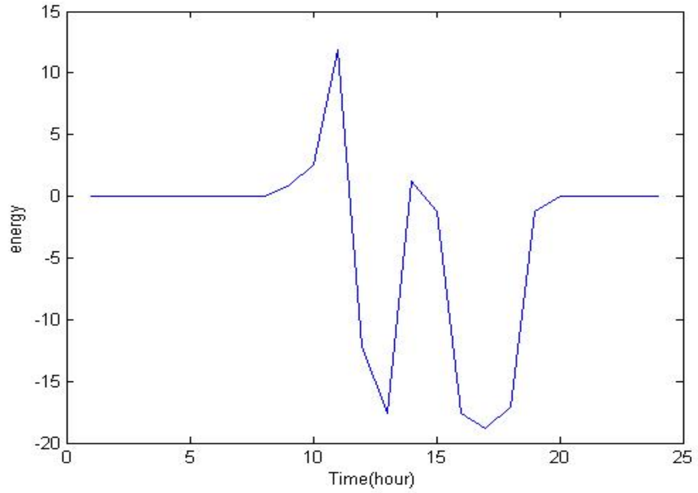


Figure 8.23: ToU tariff 3

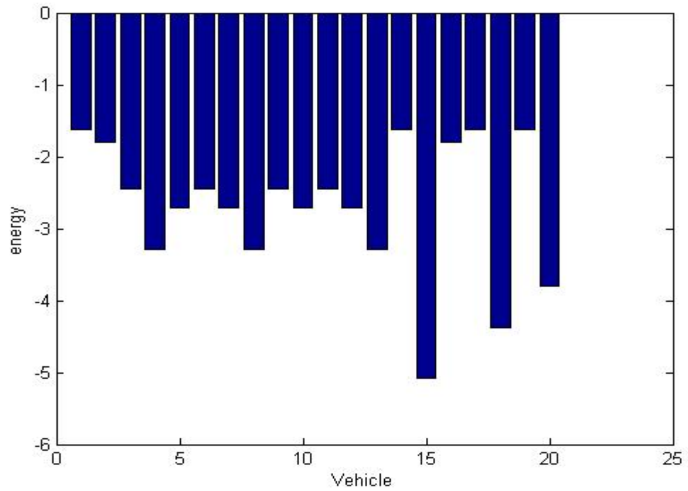


Figure 8.24: ToU tariff 4

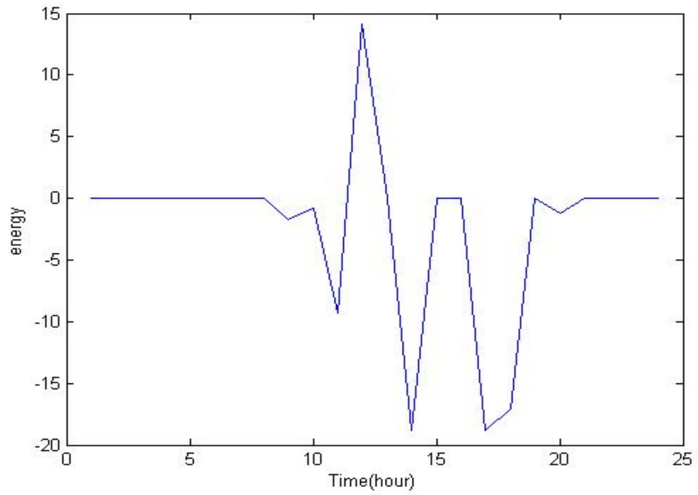


Figure 8.25: ToU tariff 4

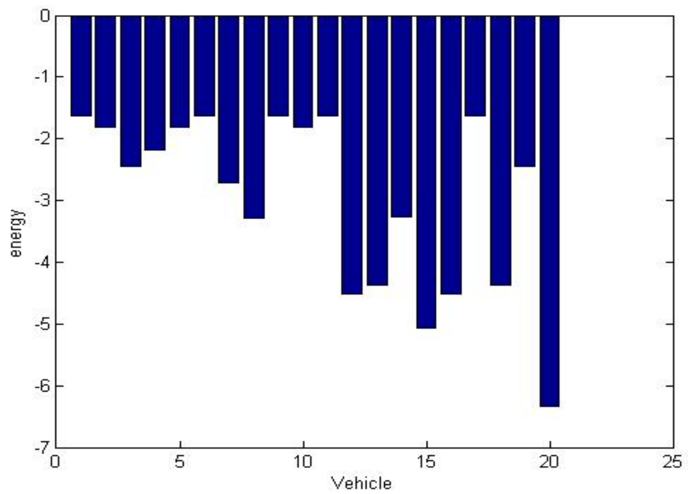


Figure 8.26: ToU tariff 5

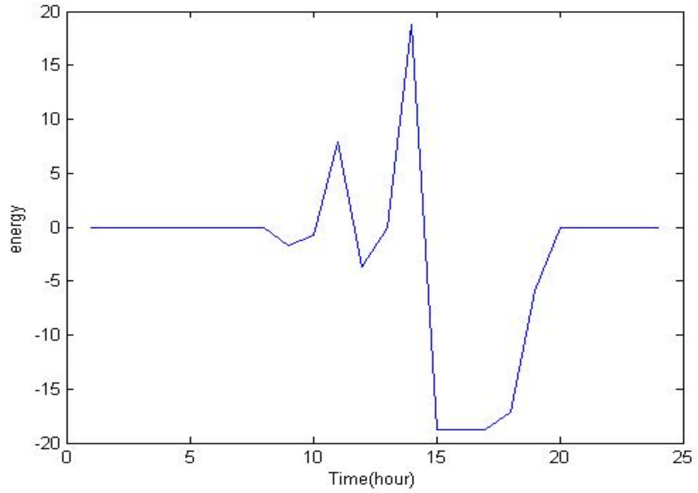


Figure 8.27: ToU tariff 5

8.3 Cost Graphs

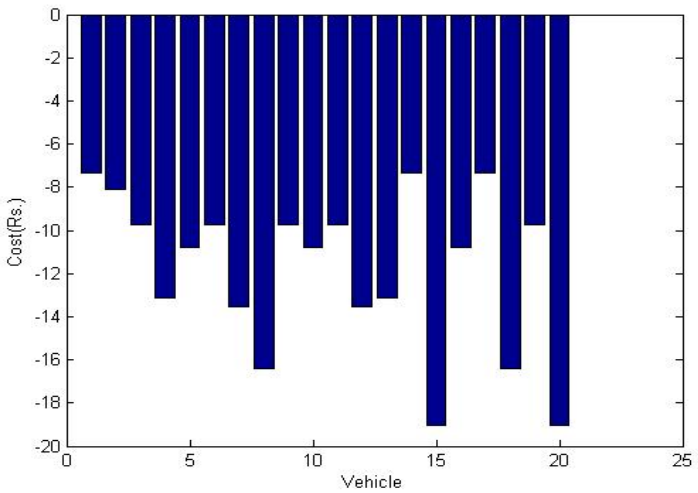


Figure 8.28: Fixed tariff 3

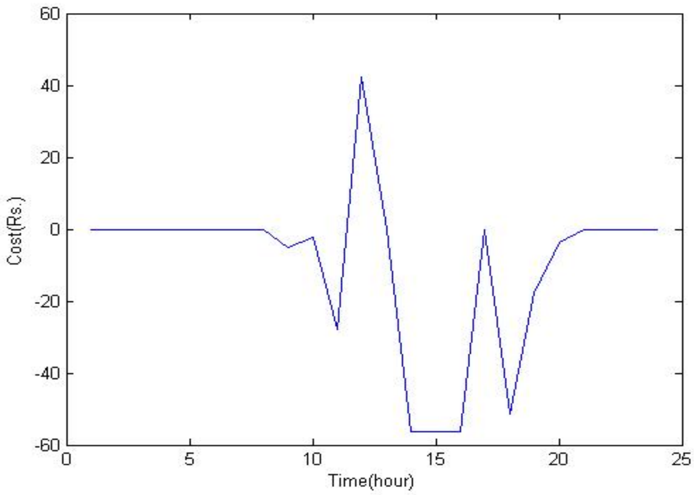


Figure 8.29: Fixed tariff 3

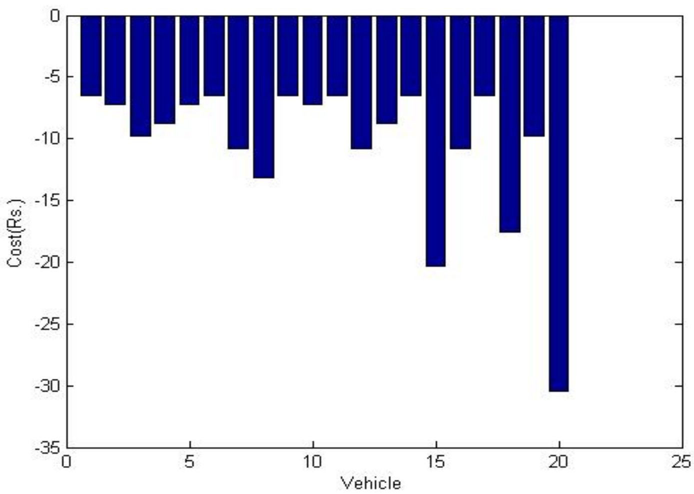


Figure 8.30: Fixed tariff 4

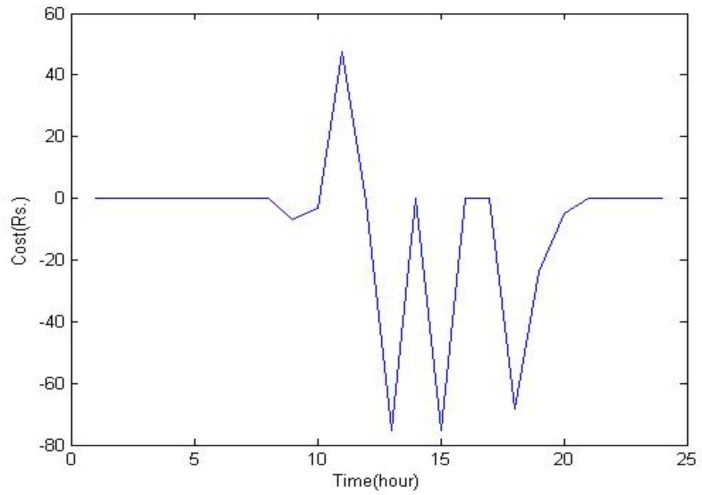


Figure 8.31: Fixed tariff 4

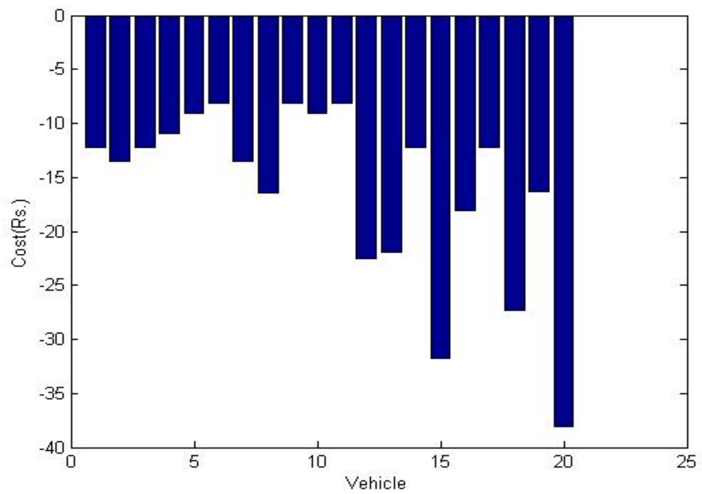


Figure 8.32: Fixed tariff 5

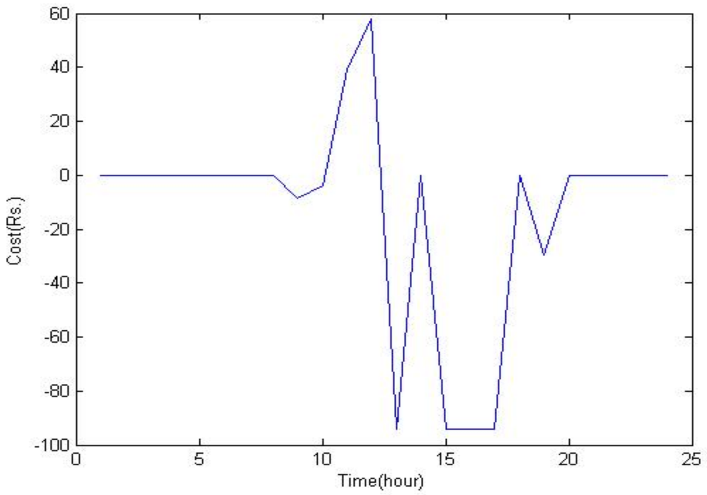


Figure 8.33: Fixed tariff 5

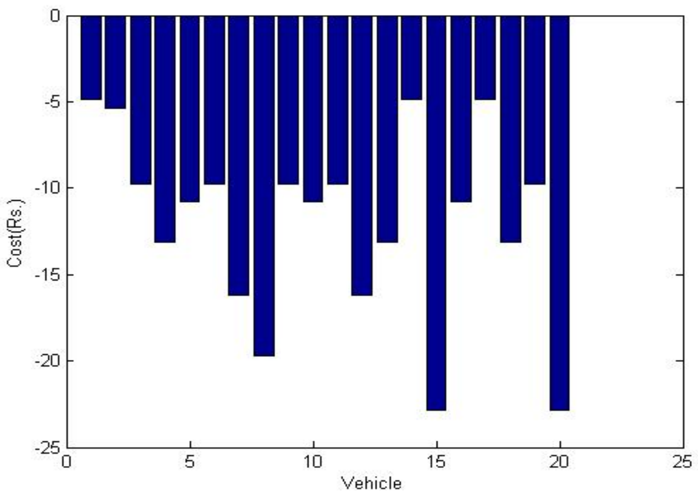


Figure 8.34: Fixed tariff 6

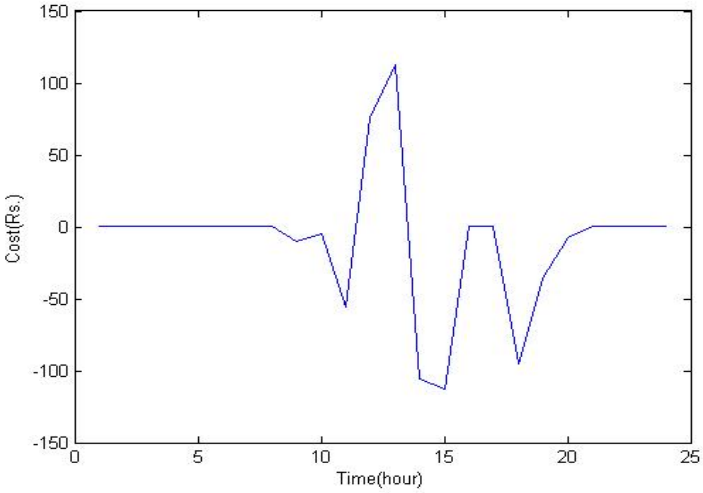


Figure 8.35: Fixed tariff 6

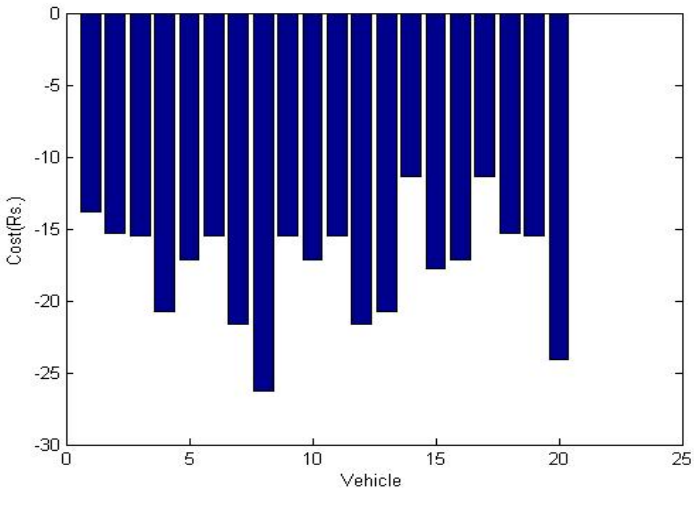


Figure 8.36: ToU tariff 1

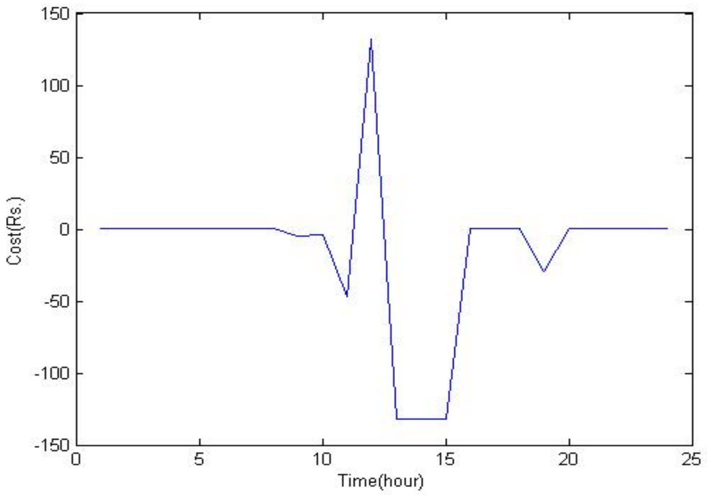


Figure 8.37: ToU tariff 1

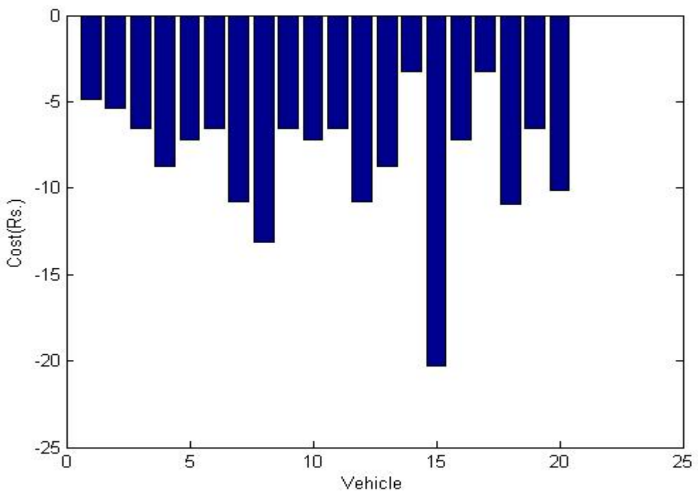


Figure 8.38: ToU tariff 2

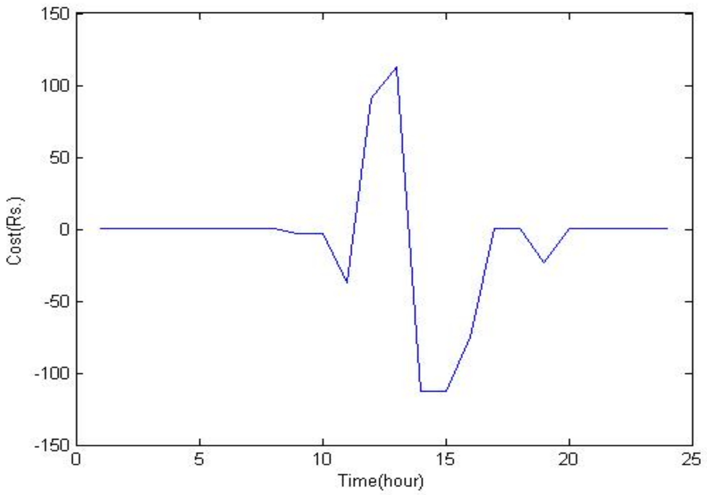


Figure 8.39: ToU tariff 2

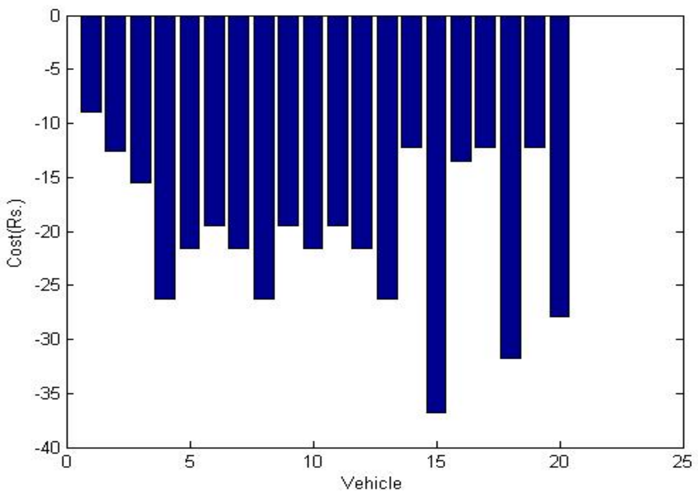


Figure 8.40: ToU tariff 3

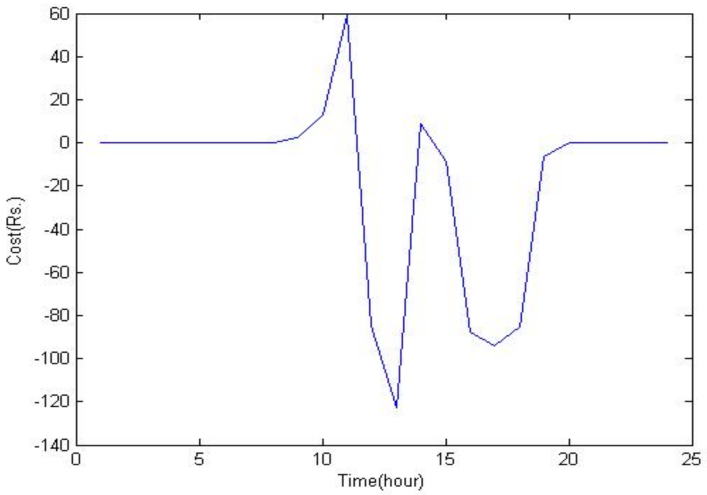


Figure 8.41: ToU tariff 3

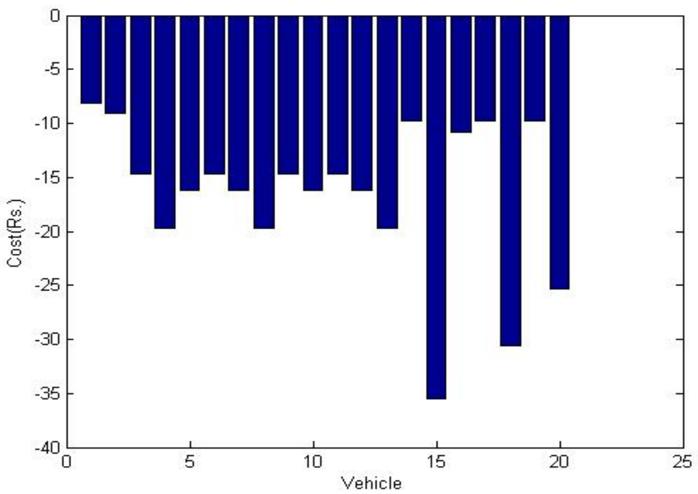


Figure 8.42: ToU tariff 4

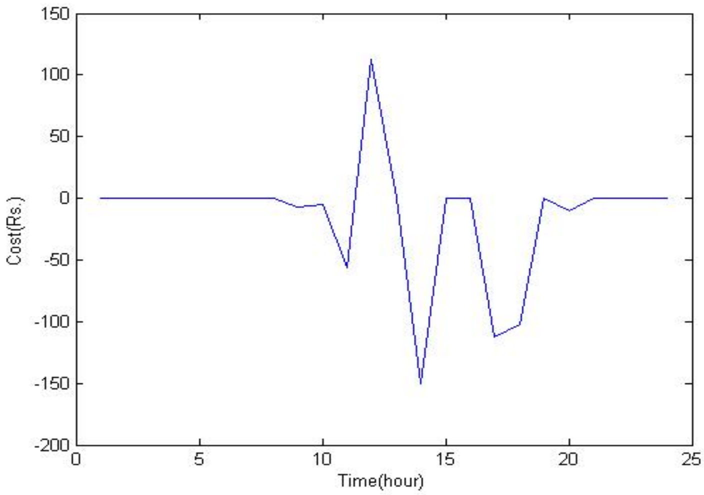


Figure 8.43: ToU tariff 4

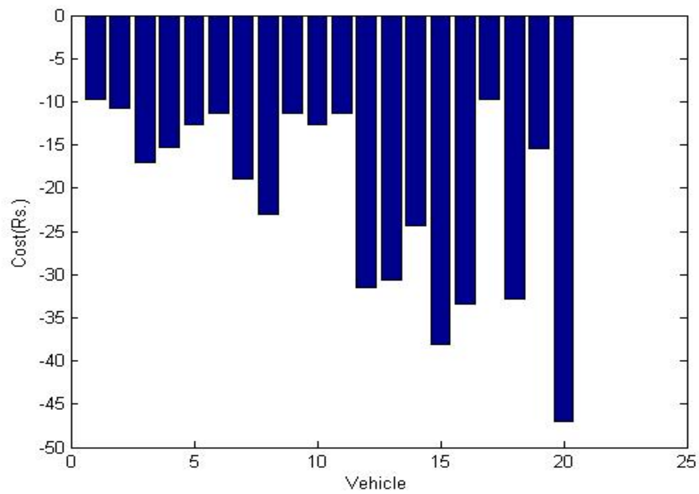


Figure 8.44: ToU tariff 5

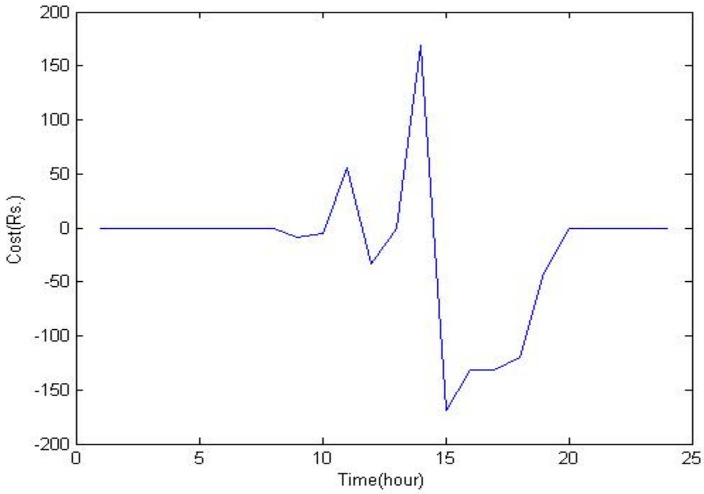


Figure 8.45: ToU tariff 5

Chapter 9

Conclusion

9.1 Conclusion

The PSO algorithm has been implemented in this work. With the help of the PSO, the optimum solution has been found out. The instant at which each vehicle has to be charged and discharged is found.Different tariff rates including Time of Use have been compared.Here,using PSO optimal charging and discharging schedules of the PHEV vehicles is found.By this schedule,the cost of charging and discharging,i.e.,the net cost can also be reduced.The title of the project,'Coordinated Energy Management of Smart Parking lots for Plug-in vehicles',is thus justified.

Chapter 10

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