In recent years, the problem of global warming has seriously become a worldwide concern. It involves issues such as the sea level rising problem and catastrophic floods. To slow down the speed of our living environment’s deterioration, the reduction of Greenhouse Gas (GHG) emissions has become urgent. As we know, the GHG are produced from multiple sectors of the economy, including industrial sources, electric power plants, residences, and agriculture; as well as the different transportation modes. And the GHG from the transportation sector can be accounted about 20 percent of the total GHG. Besides, the primary GHG produced by the transportation sector are carbon dioxide (CO$_2$), methane (CH$_4$), nitrous oxide (N$_2$O), and hydro fluorocarbons Carbon dioxide, a product of fossil fuel combustion, accounts for 95 percent of transportation GHG emissions. Therefore, if the GHG emissions from the transportation can be reduced, the global warming issues will be alleviated.

Since the Energy Intelligent Transportation System (ITS) is an emerging technique, thus there are various research directions to be addressed. The most popular research direction is how to save the fuels and how to reduce the tail gas emissions, especially the CO$_2$ emissions. Usually, vehicles’ fuel consumption rate is related to the CO$_2$ emissions rate. Therefore, the problem turns to how to improve the fuel consumption rate to achieve the goal of CO$_2$ reduction. This dissertation focuses on ITS related systems and technologies for energy saving. There are many approaches to energy saving for automobiles and road transportation. The energy saving in automobiles can be classified into two categories: the first one is the fuel consumption reduction while driving, and the second one is the total driving mileage reduction. To the first category, for the approaches to the fuel consumption reduction while driving, can include the reduction in fuel necessary for driving, and the reduction in fuel consumption by driving behavior improvement. To the second category, for the approaches of the total driving mileage reduction can include the traffic reduction while keeping the transportation volume, and the reduction in the transportation volume itself.

In this dissertation, I coped with these issues by improving vehicles’ travel efficiency from three aspects: to control the traffic light, to control the vehicles’ speed, and to control the traffic light and speed at the same time, respectively. Based on the Electronic Toll Collection (ETC) technologies, the road-to-vehicle (R2V) communications and vehicle-to-vehicle (V2V) communications were used for transmitting the real time road traffic flow conditions to the traffic control center. After obtained the road traffic flow conditions, the control center would carry out optimal traffic light control algorithms, and the OBU would work out recommended speed for the drivers.

In chapter 1, the basic concept of ITS and Energy ITS were briefly introduced. At first, the history, the underling key technologies, and the present application situations all over the world of the ITS were described, respectively. Then, the contributions to the energy saving from the ITS aspects were presented as well. At last, a brief introduction of the Vehicle to Grid (V2G) was provided. The ITS could contribute to the energy saving on two aspects: one was to eliminate the traffic congestion, which enabled each automobile to drive at the fuel optimal speeds, and the other was to provide means for modal shift, which could reduce the traffic flow.

In chapter 2, the basic knowledge of ETC and Global warming were overviewed. In section for overview of the ETC technology, the core technology of the ETC, the benefits of ETC and the ETC’s developments histories in different countries were listed, respectively. Besides, I also presented the global warming problems in this chapter. The reasons of the global warming, the worse and worse effects to the human being which brought by the Global warming, and some ways for alleviating the Global warming in our daily life were described, respectively. In the end of this chapter, I also discussed the relationship between the global warming and the public transportations. And this dissertation also indicated that reducing tail gas emissions from transportation sector was one of feasible ways for solving the global warming.

In chapter 3, a dynamic traffic light control scheme based on decision tree scheme was given out for improving vehicles’ travel efficiency. This traffic light control scheme was based on the ETC installed vehicles. In this scheme, the ETC vehicles could communicate with the traffic lights, thus the real time road traffic flow conditions would be collected in real time. And this collected road conditions information would be analyzed in the traffic control
center, then the control center would give an optimal traffic light duration time based on the traffic light control algorithm. By this dynamic traffic light control, vehicles’ travel efficiency could be improved. e.g., vehicles’ average waiting time for the red light would be greatly reduced. More important, vehicles could go through the intersection without any stops when the traffic volumes were very small. In this dissertation, I mainly focused on improving the travel efficiency by traffic light control.

In chapter 4, a recommendation speed calculation scheme was presented for improving drivers’ travel efficiency. In this chapter, the dissertation only focused on how to improve the travel efficiency from the drivers’ aspect, without considering the traffic lights. In other words, this chapter did not do anything for the traffic lights (suppose the traffic light control was the traditional fixed-time control scheme. In the recommendation speed calculation scheme), the vehicles could communicate with the traffic light based on the ETC devices, therefore, the traffic lights states would be noted before the vehicles arriving at the intersection. In this scheme, after vehicles received a recommended speed, the drivers needed to choose obey or disobey the recommended speed. If the drivers obeyed the recommended speed, they should change their current speed to the recommended speed which would help drivers to arrive at the destination with a less waiting time and less CO₂ emissions. If the drives planed to disobey the recommended speed, this scheme was also available. Compared with the without recommended speed, the drivers would arrive at their destinations with less travel time, less waiting time and less number of short-time stop-and-go. Therefore, the travel efficiency was greatly improved.

In chapter 5, detailed three-tier system architecture was given. In this three-tier architecture, dynamic traffic light control and speed control schemes were combined together and then implemented into the three-tier architecture. In tier-1, vehicles’ state information would be obtained from the GPS devices. The ETC OBUs devices could communicate with the traffic lights (in tier-2) to send current traffic flow information to the traffic control center (in tier-3) and receive traffic light phase data. The function of tier-1 mainly concerned collecting road traffic flow information data, sending traffic flow data, receiving traffic light phase data, and calculating recommended speeds. Tier-2 was mainly responsible for receiving and saving traffic flow data and then sending the control results to the ETC OBUs. This tier-2 consisted of the following three parts: 1 antennas; 2 storage; and 3 traffic lights. The purpose of the storage was used to save the received traffic flow data. The traffic lights were the displays that showed the control results. Tier-3 took responsibility for data processing, which could be divided into three sections. The first section was data extraction. As vehicles periodically sent the traffic flow information to the antenna before passing through the intersection, it might cause some problems. Therefore, it was necessary to extract the useful data from the received data. The second section was traffic light control. The control center periodically acquired the latest traffic flow data from the storage and calculated the optimal light-changing policy for this period. The third section provided an open interface for third-party applications. Vehicle information, traffic flow data, or CO₂ emissions data could be shared by third-party applications.

In chapter 6, I concluded the dissertation and stated the future works.