(57) Abstract: A vehicle 2 operable in a first emissions mode and a second emissions mode in which at least one emission from the vehicle is reduced for a given drive power compared to the first emissions mode. The vehicle is arranged to switch to the second emissions mode automatically upon determining that a current location of the vehicle is within a designated reduced-emission zone.
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Vehicle Emission Control

The present invention relates to automotive vehicles and environmental management systems, particularly those aimed at reducing the environmental impact of automotive traffic on local air quality.

In the modern world, there are an ever-increasing number of automotive vehicles such as cars, motorcycles, buses, trucks etc. on our road networks. In the last few years, the total number of vehicles being used globally has surpassed one billion for the first time. There are over 240 million vehicles in use in the United States alone, which is equivalent to 769 vehicles per 1000 people.

While the causes of global warming and climate change are often disputed, it is widely agreed that the pollutants emitted into the atmosphere through the burning of hydrocarbon-based fuels can have severe detrimental effects on the local air quality. Hydrocarbon-based vehicles that use an internal combustion engine to burn petrol or diesel typically release into the atmosphere pollutants such as carbon monoxide, nitrogen dioxide, nitrogen oxide, unburnt hydrocarbons, and particulates - often broken down into coarse particulate matter less than 10 microns in diameter (commonly denoted as PM_{10}) and fine particulate matter less than 2.5 microns in diameter (commonly denoted as PM_{2.5}).

Recently, local authorities in cities such as Paris and New Delhi have resorted to reducing the number of vehicles within the city limits by only allowing certain vehicles to enter the city based on whether their license plate number is even or odd due to the air pollution caused by heavy vehicular traffic. While these effects are widely publicised regarding large built up cities, they can also become apparent on a smaller scale.

There have been many attempts to address this problem, for example by encouraging the acquisition and use of vehicles with lower emissions rates, e.g. by using hybrid vehicles that have two or more power sources such as a combination of an internal combustion engine and an electric motor. Modern vehicles that rely only on hydrocarbon-based fuels are often equipped with an "eco mode" setting
that reduces the emissions of the vehicle through various, often manufacturer-specific means such as damping the throttle response of the vehicle or by automatically switching off the engine when the vehicle is stationary. However, these approaches rely to some extent on the driver of the vehicle being "ecologically aware", such that he or she actively chooses to engage eco mode or chooses to purchase a hybrid vehicle, which are typically more expensive than their hydrocarbon-based counterparts.

When viewed from a first aspect, the present invention provides a vehicle arranged to be operable in a first emissions mode and a second emissions mode in which at least one emission from the vehicle is reduced for a given drive power compared to the first emissions mode, the vehicle being arranged to switch to the second emissions mode automatically upon determining that a current location of the vehicle is within a designated reduced-emission zone.

Thus it will be appreciated by those skilled in the art that in accordance with the present invention a vehicle can automatically switch to a more environmentally friendly mode of operation when it finds itself within a reduced-emission zone. These zones may be established on a large scale, for example surrounding densely-populated cities; or may be on a smaller scale, for example surrounding schools or residential areas.

The first emissions mode need not automatically mean that the emissions are higher at all times while the mode prevails. For example the first emissions mode may be one that permits use of the internal combustion engine of a hybrid vehicle but depending on driving conditions etc. the electric mode may be used (as in ordinary operation) even when the vehicle is not in a designated reduced-emission zone.

Similarly, the second emissions mode may permit temporary increases in emissions - e.g. if a vehicle employs an Overtake' mode or where it is necessary to switch out of an electric mode because the battery is exhausted. More generally therefore the reduced-emission zones may dictate moving to a mode which is, on average, lower emission but that may be interpreted differently by different vehicles (subject to any possible legislation in the future).
In some embodiments of the first aspect of the invention, the vehicle is arranged to determine its current location. This may, by way of example only, comprise a global positioning system (GPS) device or the vehicle may be arranged to use radio signal-based triangulation to determine its location. The vehicle may then compare its current location to a stored list of reduced-emissions zone locations. The vehicle may, at least in some embodiments, be arranged such that if its current location corresponds to a reduced-emissions zone location stored in the list, it compares a current time with a zone activation time associated with the reduced-emission zone and switches to its reduced-emission mode only if the reduced-emission zone is currently active. This is particularly advantageous where at least some of the reduced-emission zones stored in the list are dependent on a time of day, day of week, time of year etc. For example, a reduced-emission zone around a school may only be active between the hours of 8AM and 5PM, Monday to Friday. In such situations, the vehicle can advantageously check whether or not it needs to switch to its reduced-emission mode not only based on its location but also the current time, day of the week etc. This allows the vehicle to determine whether a location is designated as a reduced-emission zone without requiring a real-time communication session with any central controller.

While the list of reduced-emission zones may be preloaded at the time of manufacture or may be updated by periodically or manually running an update function within the vehicle, in some embodiments the vehicle comprises a receiver for receiving data giving locations of one or more reduced-emission zones and storing the data. This advantageously provides the ability for a centrally managed (e.g. by a municipal authority) list of reduced-emission zones to be "pushed" to a potentially large number of vehicles simultaneously without requiring any intervention by the owner of the vehicle. This also allows the locations or activation times of the zones to be changed dynamically. In a set of such embodiments only currently active reduced-emission zones are communicated to the vehicle. This means that it is not necessary for the vehicle to determine whether the zone is active (which would rely on the accuracy of the vehicle’s clock). Taking this further, rather than being given information regarding whether particular locations are currently designated as reduced-emission zones, the vehicle could simply receive a signal telling it which mode to use or switch to.
This is novel and inventive in its own right and thus when viewed from a second aspect, the present invention provides a vehicle arranged to be operable in a first emissions mode and a second emissions mode in which at least one emission is reduced for a given drive power compared to the first emissions mode, the vehicle comprising a receiver arranged to receive a signal indicating that the vehicle is in a designated reduced-emission zone and that it should switch to the second emissions mode.

Thus it will be appreciated that, when viewed from the second aspect, the present invention provides a vehicle arranged to switch to a more environmentally friendly mode of operation when it is instructed to by a transmitted signal which could, for example, be provided by an external system controlled by a municipal authority.

In some embodiments, the signal indicates only entry into and/or exit from a reduced-emission zone. In other embodiments, it may be provided throughout the zone. This may, for example, be a radio receiver arranged to receive signals from a transmitter that broadcasts the location of the reduced-emission zone. Such a transmitter could act as a "beacon" within the reduced-emission zone that notifies incoming and outgoing vehicles as to which mode they should be operating in. Such a beacon could be installed at the centre of a particularly sensitive area such as on the roof of a school, or could be positioned in overhead gantries across a road on which vehicles enter the reduced-emission zone.

In some embodiments of either of the foregoing aspects of the invention, the reduced-emission zone is predetermined. For example, a Low Emissions Zone (LEZ) has been established in London since 2008 and similar LEZs are in effect across cities such as Berlin, Stockholm, Tokyo and Hong Kong. While these zones typically restrict the vehicles that are eligible to enter an area or levy some financial penalty on vehicles that do not meet certain emissions criteria, with at least some embodiments of the present invention, vehicles could be made to switch automatically to a lower emissions mode upon entering such a zone. Similarly, reduced-emission zones could readily be set around buildings such as schools or hospitals so that vehicles in accordance with the present invention that enter the vicinity of these buildings reduce their emissions without requiring any intervention.
by the driver. This may help to improve air quality locally around these sensitive areas.

However in alternative embodiments, the reduced-emission zone is designated dynamically. For example, it may not be necessary to keep the reduced-emissions zones in place constantly. In some such embodiments, the reduced-emission zone is dependent on a time of day, day of week, time of year etc. Using the example of a zone set up around a city, it may be that the roads within the city are relatively empty at weekends and so the restrictions could be lifted or the size of the zone could be reduced. Similarly, it may be determined that it is only important to reduce emissions around a school between the hours of 8:00 AM and 5:00 PM, and the restrictions may be eased outside these times.

In some potentially overlapping embodiments, the reduced-emission zone is dependent on a measured air quality. Environmental and meteorological agencies could have the ability to designate an area as a temporary reduced-emission zone in response to data they harvest from various sources such as air monitoring stations. Similarly, this can provide a central controller such as a municipal authority with some autonomy in deciding whether or not to apply the reduced-emissions zone based on local measurements.

It will of course be appreciated that there may be a number of reduced-emission zones, some of which may be predetermined while others are designated dynamically.

In some embodiments, the vehicle is fossil fuel driven. In some such embodiments, the first emissions mode is a regular mode of operation and the second emissions mode is a low emissions mode. Reduced-emission eco modes within vehicles are known in the art *per se*, and typically involve: damping the throttle response of the vehicle (i.e. reducing and/or "smoothing out" the rate of acceleration the engine provides when the accelerator pedal is pushed); adjusting the transmission of automatic vehicles such that the vehicle shifts to higher gears at lower revolution rates; activating a start/stop mode wherein the engine is turned off when the vehicle is stationary; reducing engine torque; adjusting the fuel trim to change the ratio of the fuel to air mixture; adjusting carburettor balance; varying the spark plug and
distributor point gaps; adjusting ignition valve timing; or any other method or combination of methods of reducing emissions.

In alternative embodiments, the vehicle is a hybrid vehicle. In some such embodiments, the first emissions mode is a fossil fuel driven mode of operation and the second emissions mode is an electrically driven mode of operation. By switching to the electrically driven mode of operation, the local emissions from such hybrid vehicles can be reduced to virtually zero. Of course, hybrid vehicles that are charged using mains electricity that is generated by a hydrocarbon-based power station will have pollutants associated with their electric mode, however the pollutants emitted will usually be far removed from urban areas (and thus have a reduced impact on humans compared to those emitted in urban and suburban areas) and can more easily be treated in situ at the power station itself.

In some embodiments of either of the foregoing aspects of the invention, the vehicle comprises an air inlet controlling ingress of air from the exterior of the vehicle to a vehicle cabin depending at least partly on whether the vehicle is in a reduced-emission zone or a specified category of reduced emissions zone. For example, if the vehicle is in a reduced-emission zone that has been designated because air pollution is high, the vehicle may reduce the ingress of air (or prevent it altogether) in order to prevent the driver and passengers being exposed to the polluted air. However, if the vehicle is in a reduced-emission zone that has been designated to keep air clean (e.g. around a school), it may determine that the ingress of air may be increased as the air should be less polluted.

In some embodiments, the vehicle comprises at least one sensor for measuring an external air quality parameter. This may provide the vehicle with a degree of autonomy in determining the local air quality and may allow the vehicle, at least in some embodiments, to contribute to the determination of whether a given area should be designated as a reduced-emission zone. In a set of such embodiments the vehicle comprises a transmitter for transmitting data from said sensor to an external server. This is beneficial in that it opens up the possibility of an external server gathering air quality data from a large number of vehicles which may not individually be able to provide very accurate data, but collectively allow an accurate statistical model to be built up. This model could further include data from one or
more high accuracy scientific air quality monitoring stations. Advantageously this may be used to provide information regarding reduced-emission zones referred to above, back to the individual vehicles in accordance with the invention.

In at least some such embodiments, the vehicle transmits data relating to a local temperature and/or humidity proximate to the vehicle. Temperature and humidity data can be useful in determining the impact that pollutants from vehicles will have as they affect the ability of the atmosphere to absorb or disperse the pollutants. High relative humidity can also increase the negative effect air pollutants have on visibility - as particulate matter such as sulfates can accumulate water from the air and expand to sizes which cause scattering of light, commonly referred to as haze.

When viewed from a third aspect, the present invention provides a method of designating one or more reduced-emission zones at one or more locations, the method comprising:

- receiving air quality data and location data from a plurality of vehicles;
- analysing said air quality data to determine at least one air quality parameter at each of said one or more locations;
- determining whether to designate a particular location as a reduced-emission zone at least partly based on said air quality parameter at said particular location; and
- transmitting information regarding designated reduced-emission zones to one or more vehicles.

Thus it will be appreciated that, when viewed from the third aspect, the present invention provides a novel, "crowd-sourced" method for determining whether or not to designate a given area as a reduced-emission zone. A system that implements such a method can harvest data from a number of vehicles, determine the quality of the air and act accordingly by selectively designating certain areas as reduced-emission zones as appropriate.

While obtaining the air quality data from the plurality of vehicles is advantageous, in some embodiments the method further comprises receiving second air quality data from one or more fixed air monitoring stations and using said second air quality data to determine at least one air quality parameter at each of said one or more
locations. By using data from both the plurality of vehicles and the fixed air monitoring stations, it is possible to monitor the air quality across a potentially larger area. The data provided by the vehicles corresponds only to the local vicinity of the roads on which the vehicles are located when they transmit their air quality data, whereas the fixed air monitoring stations can be located elsewhere.

In some embodiments of the third aspect of the invention, the method further comprises transmitting a real-time notification to a vehicle indicating that the vehicle is within a designated reduced-emission zone. This allows vehicles such as those described hereinabove with reference to the invention in the second aspect to switch to a reduced emissions mode once notified.

In some potentially overlapping embodiments, the method further comprises transmitting data to a vehicle regarding the location of one or more designated reduced-emission zones. This allows vehicles such as those described hereinabove with reference to the invention in the first aspect to switch to a reduced emissions mode automatically when entering a designated zone that the vehicle is aware of.

In some such embodiments, the data is at least partly based on a current location of the vehicle. By way of a non-limiting example, once an area has been designated as a reduced-emission zone, appropriate vehicles such as vehicles within a certain radius of the zone can be provided with up-to-date information regarding the designation of the area as a reduced-emission zone.

While a centralised system may perform the task of designating reduced-emission zones based on the air quality data that it stores locally, in some embodiments the method further comprises transmitting air quality data to a vehicle. The vehicle may use this data, for example, to control the ingress of air from the exterior of the vehicle to a vehicle cabin depending on the air quality data it receives.

In some embodiments, the method further comprises designating one or more reduced-emission zones manually. Such manual designations of reduced-emission zones can allow for certain locations of interest such as around schools, hospitals or recreational parks to be reduced-emission zones regardless of the actual air
quality at these locations at any given time with a view to keeping the air surrounding these locations as clean as possible. These manually designated reduced-emission zones may be permanent (e.g., around a school), but may also be temporary. For example, a manually designated reduced-emission zone may be arranged around an area being used for a festival or a sporting event for its duration, but resume its previous status after the event has finished.

In at least some such embodiments, the method further comprises using a map-based graphical user interface to designate one or more reduced-emission zones. This may, for example, comprise a software program that can be operated by a user working at, e.g., a municipal authority. By way of a non-limiting example only, the user could use this software program to draw the boundary of a reduced-emission zone on a map of the area using, e.g., a mouse cursor, a stylus, a touchscreen, etc. Information regarding these manually designated reduced-emission zones could then be transmitted to vehicles such as those described hereinabove with reference to the invention in the first aspect.

In some embodiments, the method further comprises using dispersion models to determine whether to designate a particular location as a reduced-emission zone. Dispersion models provide a simulation of how pollutants will move in the atmosphere given certain conditions. Such dispersion models may, by way of example only, utilise: air quality data and location data from the plurality of vehicles and/or any fixed air monitoring stations; wind speed and direction; wind turbulence; temperature; the locations of sources of pollutants and their associated emissions rates;

In some further potentially overlapping embodiments, the method further comprises:

- combining sensor data with an output from a wide area air quality model to generate combined data; and

- determining whether to designate the particular location as a reduced-emission zone at least partly based on said combined data at said particular location. This combination of sensor data and air quality model data can be achieved using a number of different techniques including but not limited to statistical data fusion and data assimilation methods. By combining the sensor data with a model such as a computer simulation of air quality in a given area, the
combined data can provide a better estimate of air quality than either source alone. For example, the sensor data and model data can be interpolated in a mathematically objective way, such that determinations as to whether an area should be designated as a reduced-emission zone can be made even if the area does not have many vehicles passing through (i.e. the sensor data is not necessarily reliable). Similarly, real world measurements associated with the sensor data can be used to constrain or adapt the model. In some such embodiments, the method further comprises combining estimates of errors associated with the sensor data and/or the wide area air quality model.

While the first and/or second data could be collected in batches, e.g. periodically or when the vehicle enters a captive network such as a Wi-Fi® network, in preferred embodiments the first and/or second air quality data are received in real-time. This advantageously allows for reduced-emission zones to be set up promptly as and when it is deemed necessary rather than waiting for data to be reported at a later time.

In some embodiments, the method further comprises using external data to determine whether to designate a particular location as a reduced-emission zone. In some such embodiments, the external data comprises weather data. Such weather data may include prevailing or forecast weather conditions such as temperature, humidity, wind speed, wind direction etc. Additionally or alternatively, in some embodiments the external data comprises traffic data. For example, if there has been a road traffic accident on a particular motorway, areas proximate to alternative routes may expect to experience a larger volume of traffic than usual until traffic returns to normal on the motorway. The weather data and/or traffic data can then be used to determine whether the air quality is likely to improve or decline based on the external data.

Certain embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 is a schematic diagram showing a car in accordance with the invention;

Fig. 2 is a schematic system diagram of a wide area air quality monitoring system in accordance with the invention;
Fig. 3 is a representative portion of an air quality data map showing different reduced-emission zones;

Fig. 4 shows an interface suitable for inputting user-designated reduced-emission zones; and

Figs. 5a and 5b show automatic operation of an air inlet on a vehicle depending on whether or not the vehicle is in a reduced-emission zone.

Fig. 1 shows a car 2 which embodies the present invention. The car 2 comprises an external air quality sensor 4 which is mounted so that it may be subjected to the air in the immediate vicinity of the car. It may, for example, be placed in the engine bay as indicated schematically in Fig. 1. The car 2 also includes an internal air quality sensor 6 which is subject to the air which is inside the cabin 8 of the car occupied by the driver and any passengers. These sensors could comprise automotive air quality sensors from SGX Sensortech SA, Corcelles-Cormondreche, Switzerland.

The car 2 also has a Global Positioning System (GPS) receiver 14 of a type well-known in the art for receiving GPS signals 16. There is also a further radio transmitter/receiver module 18 which is able to communicate by means of radio communication with a corresponding receiver/transmitter 20 which is located remotely from the car 2. This communication could, for example, be by means of a cellular data network such as 4th generation long-term evolution (4G-LTE). The remote receiver/transmitter 20 is in data communication with a remote server 22.

An air inlet 12 allows air to pass between the exterior of the car 2 and the cabin 8 dependent upon the extent to which it is open or closed. This will be described in greater detail with reference to Fig. 3.

In this case, the car 2 is a "hybrid" vehicle, wherein it can be driven by either a petrol engine 50 or an electric motor 52 at any given time as controlled by an on-board controller 54. The controller 54 is arranged to switch the car 2 between using the petrol engine 50 and the electric motor 52 as appropriate.

Conventionally, the controller 54 may switch the car 2 to its electric mode when it is travelling at low speed i.e. below some threshold speed. However, the controller 54 within the car 2 of the present invention is arranged to switch between the petrol
engine 50 and the electric motor 52 at least partly based on information it has regarding whether it is located within a reduced-emission zone.

The car 2 may obtain information regarding the locations of any reduced-emission zones in a number of ways. Firstly, the car 2 may have a list of predetermined reduced-emission zones stored locally, e.g. in the memory of the controller 54. The controller 54 may then compare the current location of the car 2 as determined by the GPS receiver 14 to the list of known reduced-emission zones. If the controller 54 determines that the car 2 is within a reduced-emission zone, it switches the car 2 to its electric mode wherein it is driven by the electric motor 52. However, if the controller 54 determines that the car 2 is not within a reduced-emission zone, it switches the car 2 to its petrol-driven mode wherein it is driven by the petrol engine 50 if it is travelling above the conventional threshold speed described previously.

Additionally or alternatively, the car may be informed of the locations of any reduced-emission zones via its radio transmitter/receiver module 18. The remote server 22 may periodically update the car 2 with a list of reduced-emission zones. The list provided by the remote server 22 may include all of the reduced-emission zones within a certain radius of the location of the car 2 as determined by the GPS receiver 14, or may be subject to a subscription list e.g. a list of reduced-emission zones within the town, county, region, country etc. in which the car 2 is registered or that the driver has chosen to receive updates about.

Alternatively, rather than the controller 54 determining whether or not the car 2 is within a reduced-emission zone, it may receive signals from the remote server 22 via the radio transmitter/receiver module 18, wherein the signals indicate to the controller 54 that the car has entered, exited and/or is currently within a reduced-emission zone such that it may act accordingly. In this case, the car 2 does not have any local information regarding the locations of any reduced-emission zones but acts according to real-time information it receives while it travels through such zones.

It will of course be appreciated that these methods may be combined - e.g. the car 2 may hold information regarding reduced-emission zones local to the driver's home
or workplace, but may receive information regarding any other reduced-emission zones from an external source when the car 2 nears them.

Furthermore, the controller 54 may determine from air quality data generated by the external air quality sensor 4 that the car 2 is located within a heavily polluted area and may decide (or be required by legislation) to try and lessen its contribution to the pollution by switching over to the electric mode of operation.

Fig. 2 shows schematically a wide area air quality monitoring system. A central mainframe computer 34 runs a statistical model of air quality over a geographic region. It receives high accuracy data from fixed scientific air quality monitoring stations 36. It may also receive feeds of weather data, traffic data, historical air quality data etc.

In addition however the computer 34 receives air quality sensor data and location data from vehicles 2, 24, 26, 28 by means of wireless data communication indicated schematically by the antennas 32. In practice these would be distributed geographically to ensure adequate coverage and would conveniently be provided by an existing cellular data network as previously described. One of these could correspond to the transceiver 20 depicted in Fig. 1. Similarly it will be appreciated that the car 2 described with reference to Fig. 1 could be one of the vehicles which interacts with the system of Fig. 2. Other vehicles 24, 26 may be of different type - e.g. trucks, vans, buses etc. but each has the capability to receive reduced-emission zone data. While the car 2 described with reference to Fig. 1 is a hybrid vehicle, car 26 is a petrol-driven vehicle that has both normal- and low-emission modes of operation.

The system can also accommodate vehicles 28 which provide air quality sensor data but do not have the capability - or (subject to local regulations) choose not - to receive reduced-emission zone data. Similarly it can also accommodate vehicles 30 which use the received reduced-emission zone data - e.g. to control emission modes - but do not or cannot provide air quality sensor data.

As will be appreciated this arrangement has the potential to provide a powerful model of air quality, particularly if a large number of vehicles 2, 24, 26, 28 provide
air quality sensor data. What is believed to be valuable here is the provision of data into the model from a (preferably large) number of vehicles to be combined with the 'scientific' data from fixed stations and, preferably, the provision of the corresponding output of the model back to at least some of those vehicles (amongst others).

If the computer 34 determines from the air quality data received from the vehicles 2, 24, 26, 28 and/or the air quality monitoring stations 36 that air pollution is particularly high in a given area, it may determine that a reduced-emission zone should be established in order to reduce air pollution in that area.

The computer 34 may, where appropriate, also make use of external data when determining whether or not to designate an area as a reduced-emission zone. For example, the computer 34 may have historical data on automotive traffic in a certain area during "rush hour" (e.g. from 8AM to 9AM) and may determine that while the air pollution is normally acceptable, if it is higher than usual prior to this time (e.g. at 7AM) then the air pollution will reach an unacceptable level in rush hour. In this case, it may therefore decide to designate the area as a reduced-emission zone in order to pre-empt the impact of regular traffic on local air quality.

The computer may also take into account composition maps and a dispersion model when determining whether or not to designate an area as a reduced-emission zone. For example, the data from one of the air quality monitoring stations 36 may suggest a high level of air pollution in a nearby area. However, the computer may determine from topographical data provided by the composition map and a model of how pollutants will disperse in the current weather conditions (e.g. temperature, humidity, wind speed etc.) that the pollutants will not affect a particular region and thus there will be no need to set it as a reduced-emission zone. Conversely, the dispersion model and composition map could suggest that the pollutants, despite starting far from a particular area of interest, may be likely to be transported to and subsequently have a detrimental effect on the area of interest.

Once the computer 34 has designated a particular area as a reduced-emission zone, it may transmit signals to one or more of the vehicles 2, 24, 26, 30 that are arranged to receive such signals in order to let them know that the
reduced-emission zone has been designated. The computer 34 may send these signals only to the vehicles 2, 24, 26, 30 that are proximate to (e.g. within a certain radius of) the reduced-emission zone, or it may send the signals to all of them. Alternatively, the computer 34 may send the signals to a selected group of the vehicles 2, 24, 26, 30 that have registered for updates on reduced-emission zones.

Particular examples of the wide area air quality monitoring system are described with reference to Fig. 3. In this example, a first reduced-emission zone 40 is established with a fixed radius surrounding a school 38. While this zone 40 may be permanent, the computer 34 may opt to selectively enable and disable the zone 40 depending on the time for day. For example, if the school and its surrounding area are typically only occupied between 8AM and 5PM, the computer may designate the surrounding area as a reduced emission zone 40 between these hours but not outside these hours. Thus, while the school is occupied, vehicular traffic is instructed to use reduced-emission modes (such as the hybrid car 2 operating using its electric motor 52 and the petrol-driven car 26 reducing its emissions e.g. by damping its throttle response).

The computer 34 may also determine from air quality sensor data provided by vehicles 2, 24, 26, 28 and/or the air quality monitoring stations 36 that air pollution is high surrounding a residential area 42. Accordingly, the computer 34 may then designate a reduced-emission zone 44 surrounding the residential area 42. As before, the change in status of this area may then be communicated to one or more of the vehicles 2, 24, 26, 30 as appropriate. This reduced-emission zone 44 may then be kept in place until such a time that the level of air pollution in the residential area 42 falls to an acceptable level.

Fig. 4 shows an interface suitable for inputting user-designated reduced-emission zones. Shown in Fig. 4 is a computer 56 which may be located in the offices of a municipal authority such as an environmental agency. The computer 56 has a monitor 58 which displays a map-based graphical user interface (GUI) 60 that a user such can interact with in order to define custom reduced-emission zones.

The user can use a mouse 62 connected to the computer 56 to move a cursor 64 along a desired path within the GUI 60 in order to draw the boundary of a new,
user-defined reduced-emission zone 66. This user-defined reduced-emission zone
66 could then, for example, be shared with suitable vehicles, for example using the
radio communication links described with reference to Fig. 2 or using the Internet.
These vehicles (such as car 2 described previously) then treat this user-defined
reduced-emission zone 66 in the same manner as the predetermined or
automatically generated reduced emission zones described with regard to Fig. 3.

Figs. 5a and 5b shows schematically automatic operation of an air inlet 64 within a
vehicle such as the car 2 described previously. The air inlet 64 includes a rotatable
flap 66 which is moved by an electromechanical actuator 70 under the control of a
microcontroller 68. This air inlet 64 is arranged such that the ingress of air into the
cabin of the car 2 is controlled at least partly depending whether the car 2 is located
within a reduced-emission zone and why the reduced-emission zone has been
designated as such. If the car 2 receives signals regarding reduced-emission
zones from the remote server 22, these signals may include information regarding
the reason for designating the area as a reduced-emission zone. For example, if
the vehicle is in a reduced-emission zone that has been designated because air
pollution is high (e.g. the reduced-emission zone 44 described with reference to
Fig. 3), the microcontroller 68 may instruct the actuator 70 to close the air inlet 12 in
order to prevent the driver and passengers within the cabin 8 from being exposed to
the polluted air. However, if the car 2 is in a reduced-emission zone that has been
designated to keep air clean (e.g. around a school such as the reduced-emission
zone 40 described with reference to Fig. 3), it may determine that the air inlet
should be opened as the air should be less polluted.

Fig. 5a shows the inlet 12 in its open configuration in which air 72 is allowed to pass
through the inlet 12 from the exterior of the car 2 to the cabin 8. However, upon the
microcontroller 68 energising the actuator 26, the flap 66 is rotated by the actuator
70 to the closed position as is illustrated in Fig. 5b thus preventing the passage of
air 72 from the exterior of the car 2 to the cabin 8. Although not shown, a fan may
also be provided to enhance airflow. This could be placed in the immediate vicinity
of the inlet 12 or at any convenient point upstream or downstream thereof.

The actuator 70 and flap 66 may have only fully open and fully closed positions as
shown in in Figs. 2a and 2b respectively (in which case air ingress could be
controlled by the speed of the fan if provided), although more typically the actuator 70 is able to control the flap 66 to a number of different intermediate positions, or indeed any intermediate position by means of a suitable control signal from the microcontroller 68. The microcontroller 68 is therefore able to exercise control over whether and to what extent air can pass from the exterior of the car 2 to the cabin 8 via the inlet 12. Of course although only a single air inlet 12 is shown, two or more may be provided in the car 2 or any other vehicle to which the invention is applied.

Thus it will be seen that the present invention provides a vehicle and method arranged to reduce emissions within a particular zone, wherein the zone can be designated as such in a number of ways including automatically, manually and based on air quality data sourced from vehicles and air quality monitoring stations. It will be appreciated by those skilled in the art that the embodiments described above are merely exemplary and are not limiting on the scope of the invention.

Although air quality has been illustrated using the example of pollution (which could take many forms such as particular gases, mixes of gas or particulates), this is not limiting and other indicators of air quality could be employed such as ozone concentrations, carbon dioxide levels etc.
Claims

1. A vehicle arranged to be operable in a first emissions mode and a second emissions mode in which at least one emission from the vehicle is reduced for a given drive power compared to the first emissions mode, the vehicle being arranged to switch to the second emissions mode automatically upon determining that a current location of the vehicle is within a designated reduced-emission zone.

2. The vehicle as claimed in claim 1 arranged to determine its current location.

3. The vehicle as claimed in claim 2 arranged to compare its current location to a stored list of reduced-emissions zone locations.

4. The vehicle as claimed in claim 3 arranged such that if its current location corresponds to a reduced-emissions zone location stored in the list, it compares a current time with a zone activation time associated with the reduced-emission zone and switches to its reduced-emission mode only if the reduced-emission zone is currently active.

5. The vehicle as claimed in any preceding claim, comprising a receiver for receiving data giving locations of one or more reduced-emission zones and storing the data.

6. The vehicle as claimed in any preceding claim, comprising an air inlet controlling ingress of air from the exterior of the vehicle to a vehicle cabin depending at least partly on whether the vehicle is in a reduced-emission zone or a specified category of reduced emissions zone.

7. The vehicle as claimed in any preceding claim, comprising at least one sensor for measuring an external air quality parameter.

8. The vehicle as claimed in claim 7, comprising a transmitter for transmitting data from said sensor to an external server.
9. The vehicle as claimed in claim 8, arranged to transmit data relating to a local temperature and/or humidity proximate to the vehicle.

10. A vehicle arranged to be operable in a first emissions mode and a second emissions mode in which at least one emission is reduced for a given drive power compared to the first emissions mode, the vehicle comprising a receiver arranged to receive a signal indicating that the vehicle is in a designated reduced-emission zone and that it should switch to the second emissions mode.

11. The vehicle as claimed in claim 10, comprising an air inlet controlling ingress of air from the exterior of the vehicle to a vehicle cabin depending at least partly on whether the vehicle is in a reduced-emission zone or a specified category of reduced emissions zone.

12. The vehicle as claimed in claim 10 or 11, comprising at least one sensor for measuring an external air quality parameter.

13. The vehicle as claimed in claim 12, comprising a transmitter for transmitting data from said sensor to an external server.

14. The vehicle as claimed in claim 13, wherein the vehicle transmits data relating to a local temperature and/or humidity proximate to the vehicle.

15. A method of designating one or more reduced-emission zones at one or more locations, the method comprising:
   receiving air quality data and location data from a plurality of vehicles;
   analysing said air quality data to determine at least one air quality parameter at each of said one or more locations;
   determining whether to designate a particular location as a reduced-emission zone at least partly based on said air quality parameter at said particular location; and
   transmitting information regarding designated reduced-emission zones to one or more vehicles.

16. The method as claimed in claim 15, further comprising:
receiving second air quality data from one or more fixed air monitoring stations; and
using said second air quality data to determine at least one air quality parameter at each of said one or more locations.

17. The method as claimed in claim 15 or 16, further comprising transmitting a real-time notification to a vehicle indicating that the vehicle is within a designated reduced-emission zone.

18. The method as claimed in any of claims 15 to 17, further comprising transmitting data to a vehicle regarding the location of one or more designated reduced-emission zones.

19. The method as claimed in claim 18, wherein the data is at least partly based on a current location of the vehicle.

20. The method as claimed in any of claims 15 to 19, further comprising transmitting air quality data to a vehicle.

21. The method as claimed in any of claims 15 to 20, further comprising designating one or more reduced-emission zones manually.

22. The method as claimed in claim 21, comprising using a map-based graphical user interface to designate one or more reduced-emission zones.

23. The method as claimed in any of claims 15 to 22, further comprising using dispersion models to determine whether to designate a particular location as a reduced-emission zone.

24. The method as claimed in any of claims 15 to 23, further comprising: combining sensor data with an output from a wide area air quality model to generate combined data; and determining whether to designate the particular location as a reduced-emission zone at least partly based on said combined data at said particular location.
25. The method as claimed in any of claims 15 to 24, wherein the first and/or second air quality data are received in real-time.

26. The method as claimed in any of claims 15 to 25, further comprising using external data to determine whether to designate a particular location as a reduced-emission zone.

27. The method as claimed in claim 26, wherein the external data comprises weather data.

28. The method as claimed in claimed 26 or 27, wherein the external data comprises traffic data.
A. CLASSIFICATION OF SUBJECT MATTER
INV. B60W20/16 B60W40/02 B60W30/182 B60H1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60W B60H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:
* "A" document defining the general state of the art which is not considered to be of particular relevance
* "E" earlier application or patent but published on or after the international filing date
* "L" document which may throw doubts on priority claim(s) one or more of which is cited to establish the publication date of another citation or other special reason (specified)
* "O" document referring to oral disclosure, use, exhibition or other means
* "P" document published prior to the international filing date but later than the priority date claimed
* "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
* "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
* "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
* "Z" document member of the same patent family

Date of the actual completion of the international search: 30 May 2017
Date of mailing of the international search report: 31/07/2017

Name and mailing address of the ISA/
European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
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Authorized officer
Dubreui l, Cedri c
INTERNATIONAL SEARCH REPORT

### Box No. II  Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

### Box No. III  Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

*see additional sheet*

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☑ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

   1-14

**Remark on Protest**

☐ The additional search fees were accompanied by the applicant’s protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant’s protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.
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This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-14
   vehicle running in a first or second emissions drive mode depending on his location within a reduced-emissions zone

2. claims: 15-28
   method for designing reduced-emissions zone(s) at particular location(s)