US 20160129925A1

(19) **United States**

(12) **Patent Application Publication**
JENSEN

(10) **Pub. No.: US 2016/0129925 A1**
(43) **Pub. Date: May 12, 2016**

(54) **FUEL CONTROL STRATEGY FOR LOCOMOTIVE CONSIST**

(71) Applicant: **CATERPILLAR INC.**, Peoria, IL (US)

(72) Inventor: **Jeffrey Edward JENSEN**, Dunlap, IL (US)

(73) Assignee: **CATERPILLAR INC.**, Peoria, IL (US)

(21) Appl. No.: **14/537,281**

(22) Filed: **Nov. 10, 2014**

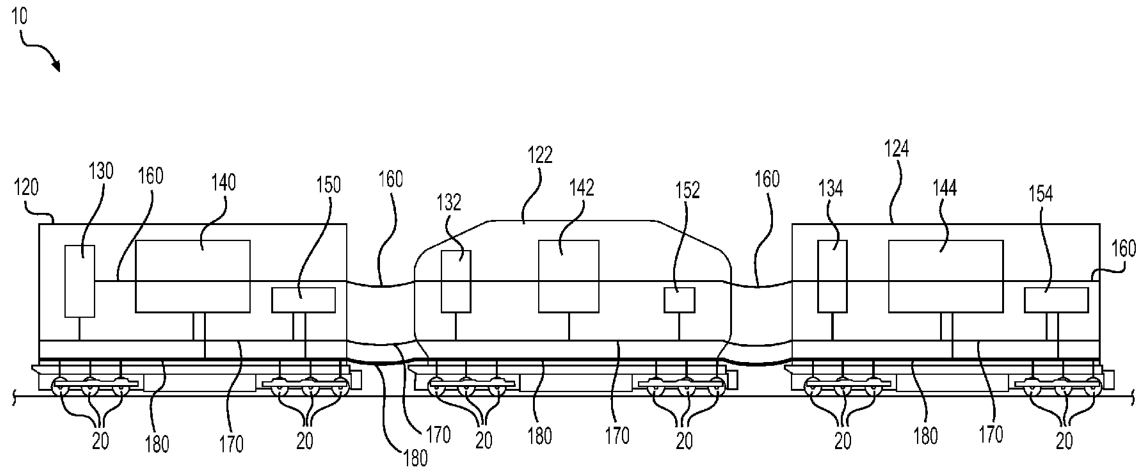
Publication Classification

(51) **Int. Cl.**
B61L 3/00 (2006.01)

(52) **U.S. Cl.**
CPC *B61L 3/006* (2013.01)

(57) **ABSTRACT**

A method of controlling the relative amounts of two or more types of fuel provided to an engine on a locomotive in a train consist includes receiving a signal at a controller on the locomotive, with the signal indicative of a current load imposed on the train consist by a rail car attached to the train consist, and a current location of the load. The relative amounts of the two or more types of fuel to be provided to the engine may be determined based upon the type of engine, the energy density of each type of fuel, the cost of each type of fuel, the availability of each type of fuel, the emissions produced by each type of fuel, the location of the engine in the train consist, and the future predicted loads imposed at different locations in the train consist as a result of a rail car attached to the consist and the terrain along the rail line. The method may also include adjusting the relative amounts of the two or more types of fuel provided to the engine based upon the determination.



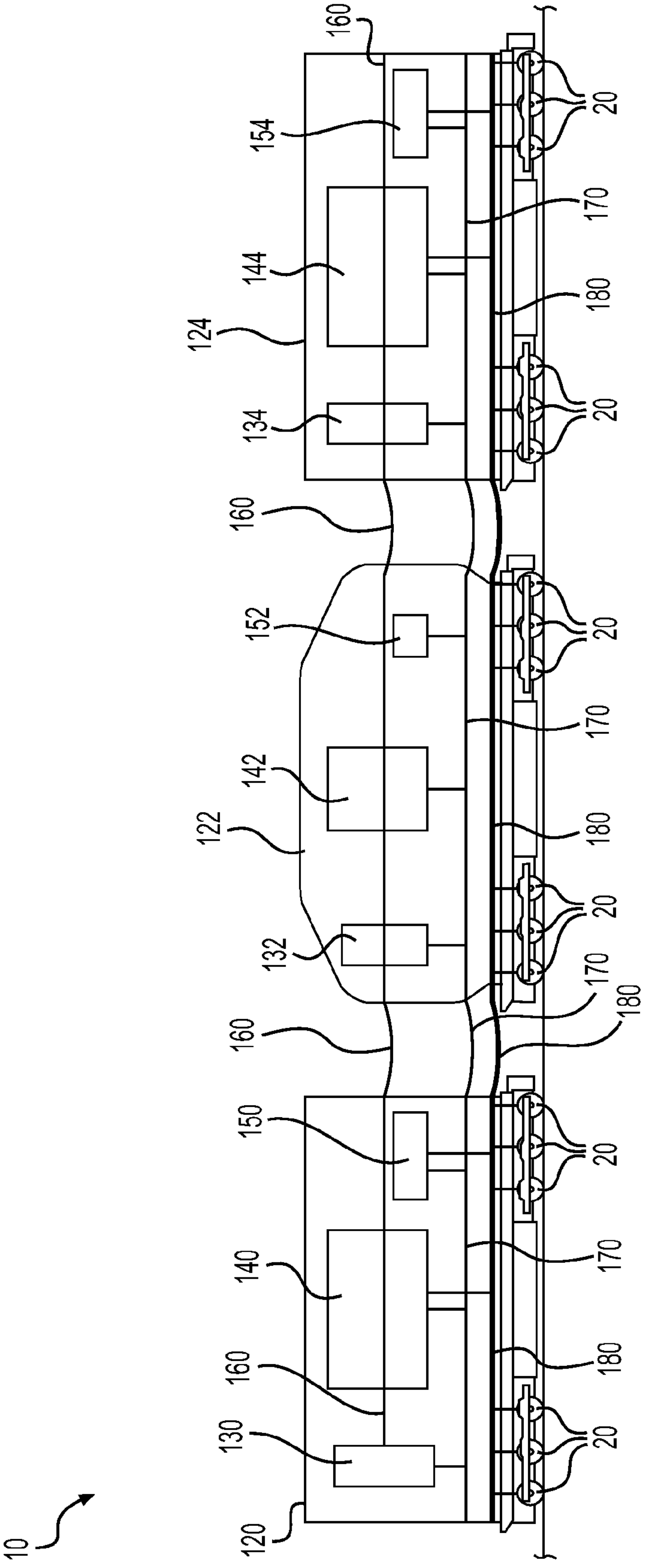

10
120
130
160
140
150
170
180
20
160
170
180
122
132
142
152
160
124
134
144
154
160
170
180
20

FIG. 1

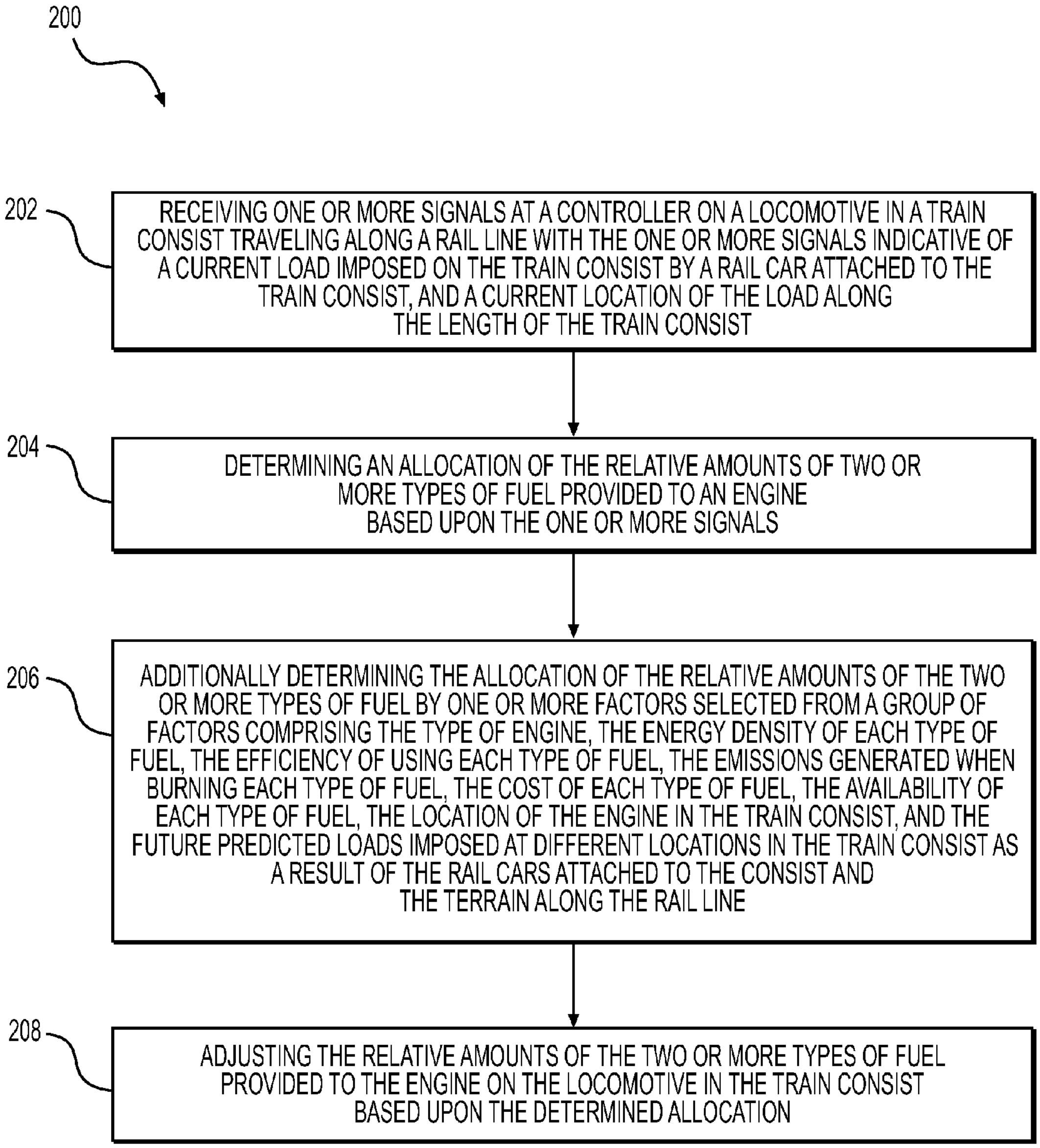

200
202
RECEIVING ONE OR MORE SIGNALS AT A CONTROLLER ON A LOCOMOTIVE IN A TRAIN CONSIST TRAVELING ALONG A RAIL LINE WITH THE ONE OR MORE SIGNALS INDICATIVE OF A CURRENT LOAD IMPOSED ON THE TRAIN CONSIST BY A RAIL CAR ATTACHED TO THE TRAIN CONSIST, AND A CURRENT LOCATION OF THE LOAD ALONG THE LENGTH OF THE TRAIN CONSIST
204
DETERMINING AN ALLOCATION OF THE RELATIVE AMOUNTS OF TWO OR MORE TYPES OF FUEL PROVIDED TO AN ENGINE BASED UPON THE ONE OR MORE SIGNALS
206
ADDITIONALLY DETERMINING THE ALLOCATION OF THE RELATIVE AMOUNTS OF THE TWO OR MORE TYPES OF FUEL BY ONE OR MORE FACTORS SELECTED FROM A GROUP OF FACTORS COMPRISING THE TYPE OF ENGINE, THE ENERGY DENSITY OF EACH TYPE OF FUEL, THE EFFICIENCY OF USING EACH TYPE OF FUEL, THE EMISSIONS GENERATED WHEN BURNING EACH TYPE OF FUEL, THE COST OF EACH TYPE OF FUEL, THE AVAILABILITY OF EACH TYPE OF FUEL, THE LOCATION OF THE ENGINE IN THE TRAIN CONSIST, AND THE FUTURE PREDICTED LOADS IMPOSED AT DIFFERENT LOCATIONS IN THE TRAIN CONSIST AS A RESULT OF THE RAIL CARS ATTACHED TO THE CONSIST AND THE TERRAIN ALONG THE RAIL LINE
208
ADJUSTING THE RELATIVE AMOUNTS OF THE TWO OR MORE TYPES OF FUEL PROVIDED TO THE ENGINE ON THE LOCOMOTIVE IN THE TRAIN CONSIST BASED UPON THE DETERMINED ALLOCATION

FIG. 2

FUEL CONTROL STRATEGY FOR LOCOMOTIVE CONSIST

TECHNICAL FIELD

[0001] The present disclosure relates generally to a fuel control strategy and, more particularly, to a fuel control strategy for a locomotive consist.

BACKGROUND

[0002] A train consist often includes a lead locomotive and at least one trailing locomotive. The lead locomotive, although generally located at the leading end of the consist, can alternatively be located at any other position along its length. In some applications a train consist may be 18,000 feet or longer, and one or more lead locomotives may be located near the front of the consist for pulling the train, while one or more trailing locomotives may be located at the rear of the consist for pushing the train. A lead locomotive may generate operator and/or autonomous control commands directed to components of the lead and trailing locomotives. A typical locomotive of a consist will have a prime mover power source that includes a diesel engine and an alternator or generator that converts rotational output of the diesel engine into electrical power. The term “prime mover” is generally used to refer to the source of power used primarily for generating a tractive effort used in moving the vehicle. A prime mover power source may also provide power for parasitic or auxiliary loads that do not contribute to the tractive effort, such as air compressors, traction motor blowers, and radiator fans. In some cases an additional auxiliary power source is included on the locomotive to provide the power needed for parasitic or auxiliary loads. Electrical power output by the prime mover power source is used primarily to drive electric traction motors, which convert the electrical power back into rotational output that drives the axles and wheels of the locomotive. A typical locomotive may have two trucks that support the body of the locomotive, with each truck including two or three axles, and each axle being driven by one of the electric traction motors.

[0003] Gaseous fuel powered engines are also common in locomotive applications. For example, the engines of a locomotive can be powered by natural gas. A preferred form of natural gas for transport with locomotives is liquefied natural gas (LNG) because of its higher energy density. The LNG can be transported in a tender car, pressurized, and heated into a gaseous state before it is delivered to a locomotive engine. The compressed natural gas (CNG) may be injected into the cylinders of the engine and ignited, such as by a spark or pilot fuel (e.g., diesel fuel). In one example, CNG is injected using high pressure direct injection (HPDI), where a high pressure pump pressurizes CNG before it is warmed to a supercritical gaseous state and then sent to an HPDI injector.

[0004] A dual fuel engine is an alternative internal combustion engine designed to run on more than one fuel, for example, natural gas and diesel, each stored in separate vessels. Such engines are capable of burning a mixture of the resulting blend of fuels in the combustion chamber and the fuel injection or spark timing may be adjusted according to the blend of fuels in the combustion chamber. For dual fuel operation where one of the fuels is premixed with air, a reduction in nitrogen oxide (NOx) and particulate matter (PM) emissions is enabled by combusting a relatively larger fraction of the premixed fuel. Relative costs and availability of different fuels are constantly in flux. Proportions of different fuels may also have an effect on the amount of power that can be produced as well as the quantity of exhaust pollutants produced by the engine. There is a need for an improved system and method for engines operating on more than one fuel so as to optimize fuel usage while meeting power requirements and emission standards.

[0005] Communication between the lead and trailing locomotives can involve a hard-wired multi-unit (MU) cable, which carries signals indicative of a desired power level for the consist. The MU cable includes several wires that carry signals indicative of different throttle notch settings (predefined discrete power levels). Most of these signals are binary indicators that either provide a voltage or no voltage to the wires. Known methods for controlling a consist of at least first and second locomotives include providing control signals from a lead locomotive over the MU cable to command discrete operating modes for each locomotive in a consist. Such a method is disclosed in U.S. Pat. No. 7,021,588 that issued to Hess, Jr. et al. on Apr. 4, 2006 (“the ’588 patent”). The method in the ’588 patent comprises receiving a control command and determining a power operating mode of the first locomotive and a power operating mode of at least the second locomotive as a function of the control command and an optimization parameter.

[0006] Although the system of the ’588 patent may provide improved communication and power control between multiple locomotives in a consist, there is still room for improvement. In particular, existing train consists may not take full advantage of the differences in prices and energy densities of various fuels that may now be used to run the prime mover power sources on the locomotives.

[0007] The method of the present disclosure solves one or more of the problems set forth above and/or other problems in the art.

SUMMARY OF THE INVENTION

[0008] In one aspect, the present disclosure is directed to a method of controlling the relative amounts of two or more types of fuel provided to an engine on a locomotive in a train consist traveling along a rail line. The method may include receiving one or more signals at a controller on one of the locomotives, with the one or more signals indicative of a current load imposed on the train consist by a rail car attached to the train consist, and a current location of the load. The method may also include determining the relative amounts of the two or more types of fuel to provide to an engine operating as a prime mover on the train consist based upon one or more of factors selected from a group of factors comprising the type of engine, the energy density of each type of fuel, the efficiency of using each type of fuel, the cost of each type of fuel, the availability of each type of fuel, the emissions produced by each type of fuel, the location of the engine in the train consist, and future predicted loads imposed at different locations in the train consist as a result of one or more rail cars attached to the consist and the terrain along the rail line. The method may still further include adjusting the relative amounts of the two or more types of fuel provided to the engine based upon the determination.

[0009] In another aspect, the present disclosure is directed to a fuel controller configured to control the relative amounts of two or more types of fuel provided to an engine on a locomotive in a train consist traveling along a rail line. The fuel controller may be configured to receive one or more signals indicative of a current load imposed on the train consist by a rail car attached to the train consist, and a current location of the load. The fuel controller may be further configured to determine an allocation of the relative amounts of the two or more types of fuel provided to the engine based upon the one or more signals. The fuel controller may be still further configured to additionally determine the allocation by one or more factors selected from a group of factors comprising the type of engine, the energy density of each type of fuel, the efficiency of using each type of fuel, the emissions generated when burning each type of fuel, the cost of each type of fuel, the availability of each type of fuel, the location of the engine in the train consist, and the future predicted loads imposed at different locations in the train consist as a result of the rail cars attached to the consist and the terrain along the rail line. The fuel controller may also be configured to adjust the relative amounts of the two or more types of fuel provided to the engine on the locomotive in the train consist based upon the determined allocation.

[0010] In a further aspect, the present disclosure is directed to a train consist including one or more locomotives with multiple fuel control strategies. The train consist may include a plurality of locomotives, with one or more of the locomotives including at least one engine producing a rotational output, an electrical power generator coupled to the rotational output of the engine and configured to generate electrical power when being rotated by the rotational output, and a plurality of electric traction motors driven by electrical power generated by the electrical power generator. The one or more locomotives may further include at least one controller configured to receive one or more signals, with the one or more signals indicative of a current load imposed on the train consist by a rail car attached to the train consist when the train consist is traveling along a rail line, and a current location of the load. The at least one controller may be further configured to determine an allocation of the relative amounts of two or more types of fuel provided to each of the at least one engine based upon the one or more signals. The at least one controller may be still further configured to additionally determine the allocation based upon one or more factors selected from a group of factors comprising the type of engine, the energy density of each type of fuel, the efficiency of using each type of fuel, the emissions generated when burning each type of fuel, the cost of each type of fuel, the availability of each type of fuel, the location of the at least one engine in the train consist, and future predicted loads imposed at different locations in the train consist as a result of the rail cars attached to the consist and the terrain along the rail line. The at least one controller may be configured to adjust a ratio of the two or more types of fuel provided to the at least one engine based upon the determined allocation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. **1** is a diagrammatic illustration of a train consist including prime mover power sources, a smart rail car, and auxiliary power sources that may include dual fuel or multiple fuel engines.

[0012] FIG. **2** is a flow chart depicting an exemplary disclosed method of controlling the relative amounts of two or more types of fuel provided to an engine on a locomotive of the train consist shown in FIG. **1**.

DETAILED DESCRIPTION

[0013] FIG. **1** illustrates an exemplary train consist **10** having a lead locomotive **120**, a smart rail car **122**, and a trailing locomotive **124**. In alternative implementations, a locomotive other than locomotive **120** may be the lead locomotive of the consist. In some implementations, additional or fewer locomotives may be included within the consist. The locomotives shown in FIG. **1**, whether individually or in a consist as shown in FIG. **1**, may also be located at a front end of the train consist, in a middle section of the train consist, or at the end or trailing portion of the train consist. One of ordinary skill in the art will recognize that the train consist **10** may have any number of different locomotives and rail cars arranged in many different possible configurations. Each locomotive **120**, **124** may include one or more power sources. In the exemplary implementation illustrated in FIG. **1**, each locomotive **120**, **124** includes a prime mover power source **140**, **144**, respectively, and an auxiliary power source **150**, **154**, respectively. Prime mover power sources **140**, **144** may each include a relatively large dual fuel engine and an alternator or generator. The prime mover power source converts the energy derived from a combination of fuels into electrical power that may then be provided to an electrical power bus **180**. Auxiliary power sources **150**, **154** may similarly each include engines in combination with an alternator or generator. The auxiliary power sources may include dual fuel engines that are smaller than the dual fuel engines of the prime mover power sources, since the auxiliary power sources may provide power primarily for parasitic loads rather than for tractive effort. Alternative implementations may include other types of engines such as gas turbines. References to “dual fuel” engines throughout this disclosure will be understood to also include engines that are able to run on more than two different types of fuel. The alternator included with each prime mover power source **140**, **144** and with each auxiliary power source **150**, **154** may be coupled with a rectifier to output DC electrical power to electrical power bus **180**. Alternative implementations may also include providing AC electrical power to electrical power bus **180**. If alternators coupled to each dual fuel engine output AC electrical power to electrical power bus **180**, additional circuitry or controls may be required to synchronize each of the alternators, and the AC power from power bus **180** may require conversion to DC power through rectification, and then additional conversion at each traction motor to supply power in a form required by the traction motors.

[0014] As shown in FIG. **1**, and in accordance with various implementations of this disclosure, each of the prime mover power sources **140**, **144**, and the auxiliary power sources **150**, **154** may be electrically coupled in parallel to the electrical power bus **180** that may run through all of the locomotives in the consist, and may even extend between locomotives **120**, **124** at opposite ends of the train consist **10** and along one or more “smart” rail cars **122** attached to the train consist in between the locomotives **120**, **124**. The one or more smart rail cars **122** may also include one or more controllers **132**, memory storage devices **142**, and sensors **152**. As explained in more detail below, the one or more controllers **132**, memory storage devices **142**, and sensors **152** located on each smart rail car **122** may provide the smart rail car **122** with the ability to include and transmit updated data specifically associated with the rail car that may be used by a controller **130**, **134** on a locomotive **120**, **124** of the train consist **10** to affect, improve or monitor operations of the train consist **10**. Traction motors **20** mounted on trucks of each of the locomotives **120**, **124**, and if desired, in some implementations even on powered smart rail cars **122**, and drivingly coupled to the axles of each locomotive and smart rail car, may also be electrically coupled in parallel to the electrical power bus **180**. The provision of mechanical-electrical power sources on each of the locomotives **120**, **124**, and in some implementations, on one or more powered smart rail cars **122**, all connected in parallel to a common electrical power bus **180** that runs through all of the locomotives **120**, **124** and smart rail cars **122** in the train consist **10**, may enable power sharing between the locomotives and the smart rail cars. Electrical power can be provided by one or more power sources on any one of the locomotives in the consist. Each traction motor **20** on each of the locomotives and smart rail cars may also be operated at times in a regenerative braking mode that converts the traction motor from an electrical load into another source of electrical power that may be provided to the common electrical power bus **180**. The ability to share power between the locomotives and smart rail cars using the common electrical power bus **180** may be particularly useful in the exemplary implementations of the present disclosure wherein power output by each of the dual fuel engines throughout the train consist **10** may vary frequently as a function of changes to the ratios of the different types of fuel provided to the engines on the locomotives. The ability to control the power output of a dual fuel engine by varying the ratios of the different types of fuel being provided to an engine may further compliment the flexibility provided by sharing electrical power over the common electrical power bus **180**.

[0015] Controllers **130**, **134** may be provided on each of locomotives **120**, **124**, and may be communicatively coupled through a common control bus **170** extending through all of the locomotives to control modules on each of the power sources. The one or more controllers **132** provided on one or more smart rail cars **122** also connected to the train consist **10** may also be communicatively coupled through the common control bus **170**. Each controller **130**, **134** on each locomotive **120**, **124**, respectively, may include dual fuel controls, engine operating parameter controls, electrical power output controls for an associated alternator or generator, electrical power controls for an associated traction motor, and locomotive controls. In some implementations, the controller **132** on the one or more smart rail cars **122** may also include electrical power controls for associated traction motors on a powered smart rail car. In some implementations the controllers **130**, **134** on locomotives **120**, **124** may additionally include exhaust aftertreatment system (ATS) controls if ATS hardware is included on the associated locomotive. A lead locomotive of the consist may include a lead controller communicatively coupled over a multi-unit (MU) cable **160** to controllers on each of the one or more trailing locomotives, to the controller **132** on the one or more smart rail cars **122**, and/or to additional consists of locomotives that may be connected in the train consist **10** in a trailing position and separated from a lead locomotive consist by additional smart rail cars. Each controller **130**, **132**, **134** may include one or more processors, or various combinations of software and hardware, or firmware configured to execute instructions, such as routines, programs, objects, components, or data structures that perform particular tasks or implement particular abstract data types. In various alternative implementations signals may be transmitted to and from the controllers over wireless networks, using radio frequency signals, cellular signals, or combinations of known or still-to-be-developed communication technologies. Alternatively or in addition, one or more controllers may also be provided at remote locations such as at wayside stations or dispatch centers, and may be in communication with the locomotives over wireless networks.

[0016] Various fuel control protocols implemented by one or more of the controllers may designate the allocations of multiple fuels provided to each of the prime mover power sources **140**, **144**, and/or to the auxiliary power sources **150**, **154**, depending on information received by the controllers. The information received by the controllers may include information that is acquired from data sources on or off of the train, such as maps or other databases, or provided from various sensors located at different positions along the train, as well as from computer chips, memory devices, or other sources of stored or acquired data included on one or more of the rail cars connected to the train. As the costs of sensors have dropped, and the ability to store and transmit large quantities of data has increased, the ability to provide real time information specific to each of the smart rail cars **122** in a consist has also improved. Each of the rail cars **122** attached to the train consist **10** may be manufactured or retrofitted as a "smart" rail car that is capable of being plugged into the MU cable **160** or otherwise placed into communication with a control computer on the train when the smart rail car is connected to the train. Each smart rail car **122** may include the controller **132**, one or more memory devices **142**, and sensors **152** capable of being communicatively coupled to MU cable **160** and common control bus **170**. A "smart" rail car refers to the ability of the rail car to include and transmit updated data specifically associated with the rail car that may be used by a controller on a locomotive of the train to affect, improve or monitor operations of the train. The data provided by each smart car may be used for functions such as providing more accurate planning and adjusting of freight schedules for the train, reducing total operating costs for the train, improving overall fuel consumption, monitoring maintenance intervals, reducing emissions, improving longevity of the rail cars, improving safety, and other functions. A smart rail car may include a freight car, a passenger car, a fuel tender car, or any other type of rail car connected to a train. The information provided by a smart rail car when it is connected to the train may include what type of rail car is being connected, what product or payload is being carried by the rail car, the current location of the rail car being connected, future predicted locations and changes in the load being carried by the rail car, what percentage of full capacity the rail car is during all times when the rail car is connected to the train, the distribution of the load on the rail car, when the last maintenance was performed on the rail car, the age of the rail car, and other potentially relevant information.

[0017] Each of the controllers **130**, **132**, **134** may further include one or more memories, one or more algorithms, and one or more computer processors. Each memory may be configured to store predefined information associated with the locomotive or smart rail car on which the controller is located, information regarding any additional locomotives and rail cars connected to the train, as well as information regarding an upcoming trip profile. For example, the memory may store information relating but not limited to temperatures and pressures associated with the engine, fuel injection timing and pressures, engine speeds, power outputs of the engine, engine emission levels, fuel usage levels, engine loads, fuel costs, fuel availability, distances between various points along a predefined path over which the train will travel, terrain profile associated with the path, ambient temperature and pressure, time required to traverse the distance, and location of one or more fuel stations along the predefined path, or the like. Furthermore, the memory may be configured to store actual sensed/detected information from the above-mentioned sensors. Data acquired during previous trips of the train may also be stored in order to allow the processor to learn from and continuously improve trip performance parameters and costs. The one or more algorithms may facilitate the processing of signals from the above-mentioned sensors.

[0018] The one or more processors may include a microprocessor, a programmable logic controller, a logic module, etc. When dual fuel engines are being used, each processor in combination with one or more algorithms may be used to perform various computational operations relating to determination of an allocation of a plurality of types of fuels to be delivered to each cylinder of each engine acting as the prime mover on a locomotive. For example, if an engine on a locomotive is a dual fuel engine utilizing diesel and natural gas, then the allocation of the plurality of fuels would be the ratio of diesel to natural gas to be delivered to each cylinder. Each of the plurality of fuels may be drawn from a separate source on the locomotive or from a separate tender car connected directly to the locomotive or otherwise included in the train.

[0019] The one or more processors may be configured to determine the allocation of the fuels provided to each engine cylinder based on a plurality of parameters. In some implementations, the one or more processors may determine allocations of the plurality of fuels based on outputs from various sensors taken by themselves or in combination with information provided to the processors from each of the “smart” rail cars connected to the train consist. As discussed above, the smart rail cars may be provided with capabilities that include identifying to the locomotives on a train exactly what type of car the rail car is, what load the rail car is carrying, what percentage of full capacity the rail car is when connected to the train, future predicted loads and locations of the rail car, the age of the rail car, the maintenance performed on the rail car, information relating to electronic communication and control capabilities of the car, and other relevant information. In certain implementations, a processor may determine a ratio of the types of fuel to be burned by an engine based at least in part on output from location sensors. Location sensors may include global positioning system (GPS) sensors, radio frequency identification devices (RFID), and other location calculating systems that may include one or more of speedometers, tachometers, and timers. Additionally or alternatively, the processor may utilize information from location devices in conjunction with the information from sensors **152** such as load cells on each of the smart rail cars **122**, and other relevant information provided by the smart rail cars **122** to determine the ratios of fuels. One or more processors may also use information stored in memories or provided by remote sources of information such as a dispatch center, including freight schedules, current and future train locations, the total number and types of rail cars already connected or to be added to the train, terrain information, weather conditions, and desired trip plans. Trip plans may be predetermined based upon desired fuel consumption and emission levels along the path over which the train will be traveling, and may be constantly updated based upon predicted and unforeseen changes that may occur as the train travels along the path. In some implementations, trip plans may also be at least partially determined by regulations specifying parameters such as emission levels allowed in certain regions, speed limits, noise levels, and other considerations. The processors may output control signals to a fuel delivery system so as to deliver the desired ratios of a plurality of fuels to the cylinders of the engines based on the determined fuel ratios.

[0020] The fuel ratios may be determined at least in part based on the actual loads that will be imposed on the train at different locations along the train. These loads may be a function of the total weight of a particular rail car, the percent loaded and distribution of the load on the rail car, rolling friction of the rail car, drag resistance on the rail car caused by wind, the location of a loaded rail car relative to the terrain over which the car is traveling, and the condition of the track over which the car is traveling. In one exemplary implementation, a loaded rail car at a rear end of a train may be imposing very little additional load on the train when that portion of the train is traveling downhill. Information provided by each of the smart rail cars including the instantaneous weight of the rail car, its location in the train, and its location relative to the terrain over which the train is traveling may allow a processor to determine how much power is needed from the prime mover engines in various locomotives of the train. In-train forces (sometimes also referred to as drawbar pull), or the mechanical loads on the train couplings caused by factors such as differences in the terrain and the weight of rail cars at different positions along the train may also be taken into consideration. In a situation where heavily loaded rail cars are located toward a rear end of a long train, and that rear end portion of the train is traveling uphill, while a front end portion of the train is traveling downhill, more power may be needed from engines located on the locomotives at the rear end of the train in order to provide additional pushing force up the hill. This may help to avoid increasing tension loads on the rail car couplings beyond a threshold level. A dual fuel engine burning diesel fuel and compressed natural gas (CNG) may produce more power when it is provided with a higher ratio of diesel fuel to CNG. Therefore, a processor may determine the allocation of the various types of fuel to different engines along the train based upon real time power needs at a particular location along the length of the train consist, location relative to the terrain along the rail line, desired emission levels, availability of the different types of fuel, and other factors. The processor may also attempt to maintain a plurality of actual values associated with usage of the plurality of fuels to less than or equal to predefined corresponding threshold values. In one exemplary implementation, an actual cost associated with usage of the plurality of fuels may be maintained to less than or equal to a predefined threshold cost. In another implementation, an actual emission level associated with usage of the plurality of fuels may be maintained to less than or equal to a predefined threshold emission level. In yet another implementation, an actual quantity of a particular type of fuel available on the train at any particular point in time may be taken into consideration.

[0021] The parameters discussed herein may dynamically vary as a function of time and location of the train. Freight schedules may change, trip plans or profiles may change, the terrain over which the train is traveling may change, weather conditions may change, and the loads imposed by different rail cars at different locations along the train may change as the rail cars are added to the train, removed from the train, filled, or unloaded. Hence, the one or more processors may determine the allocations of various types of fuels and the ratios of the types of fuels as a function of time and a corresponding location of the engine to which the fuels are being provided. The frequency of sensing and/or retrieving the various parameters and determining the fuel ratios may vary depending on the type of application. In certain implementations, one or more processors may also output data to and receive data from a user interface in order to allow for operator inputs and monitoring, both on the train and from remote locations such as a dispatch center. A fuel delivery system may be controlled based on the determined fuel ratios.

[0022] The electrical power provided to power bus **180** by a dual fuel engine in combination with an alternator on one of the locomotives in the consist may provide all the power that is needed during designated periods of time to operate traction motors **20** on any of locomotives **120**, **124**, and smart rail cars **122**, and to provide power to any parasitic loads such as traction motor fans, onboard air conditioning, air compressors, or other non-tractive loads. These low power demand periods of time may occur, for example, when the train is traveling down a steep grade, and each of the traction motors **20** is in a regenerative braking mode. Energy management protocols initiated by one or more of the controllers **130**, **132**, **134** may enable the selective operation of one or more dual fuel engines on any or all of the locomotives in a consist. The energy management protocols may also be provided with the additional flexibility in accordance with various implementations of this disclosure to vary the ratios of the types of fuels provided to each of the dual fuel engines on any particular locomotive consist, as well as varying the ratios of the types of fuels provided to engines on locomotives that are located in completely different locomotive consists at other locations along the train. Various operational situations may occur where any particular locomotive in one or more locomotive consists at any location along the train consist **10** may be able to obtain an extra boost of power from electrical power bus **180** even though the power sources on the particular locomotive are also operational. A locomotive with a temporarily malfunctioning power source may also be able to continue to meet auxiliary and/or tractive power needs by drawing power from electrical power bus **180**. The fuel ratios provided to other engines on other locomotives that are functioning normally may be varied in order to generate the extra power that may be needed when an engine is malfunctioning. The power sharing arrangement in accordance with various implementations of this disclosure may also allow for all power sources on some of the locomotives to be turned completely off during periods of time when both tractive and auxiliary power demands on each locomotive are being met by power obtained from the common electrical power bus **180**.

[0023] In some implementations of this disclosure the electrical power provided to electrical power bus **180** by one or more of the power sources on the consist may be controlled to maintain a certain minimum voltage on the electrical power bus at all times. As one non-limiting example, a minimum voltage falling approximately within the range from 600 volts to 1200 volts may be maintained on electrical power bus **180** at all times. One or more of controllers **130**, **132**, **134** may be configured to receive input data and provide command control signals for operating the fuel ratios provided to any of the dual fuel power sources on any of the locomotives in the consist to maintain this minimum voltage on electrical power bus **180**. Input may be provided to the controllers from operators onboard the locomotives, or from other command control centers, dispatch centers, or wayside stations. Additional signals received by the controllers may include signals indicative of operating parameters for each traction motor **20**, operating parameters and power generating capacities of each alternator or generator, duty cycles for each alternator or generator, track profile information including track grade, curvature, elevation, tunnels, speed limits, road crossings, and switchyards, power available on electrical power bus **180**, trip plan information, and actual power utilization rates on each locomotive for both tractive effort and other parasitic or auxiliary loads.

[0024] The controllers may be configured to process the information received from various sensors and other inputs providing the data discussed above and maintain the minimum voltage on electrical power bus **180** by controlling the fuel ratios provided to one or more power sources as needed. Maintenance of a minimum voltage on electrical power bus **180** at all times may provide a benefit in that ancillary power on any of the locomotives for air compressors, traction motor blowers, radiator fans, and other parasitic loads is available from electrical power bus **180** at all times. Furthermore, maintenance of at least a minimum voltage on electrical power bus **180** may help to reduce power losses over the power bus by allowing for a lower current through the bus. Because of the relationships between power (P), voltage (V), current (I), and resistance (R), in a power bus with a resistance R, where V=IR, P=IV, and accordingly $P=I^2R$, the power loss over the power bus may be referred to as an I^2R loss. A higher potential or voltage (V) in a power bus having a substantially constant resistance (R) may result in substantially the same amount of electrical power (P) transferred through the bus at a lower current (I). A lower current translates into lower power losses, and may also enable the use of an electrical cable with a smaller cross sectional area, which may further reduce costs by cutting down on the amount of copper needed to produce electrical power bus **180**.

[0025] One or more controllers on any of the locomotives and/or smart rail cars may also be configured to transfer excess electrical energy from electrical power bus **180** to various energy storage devices. One or more of the locomotives in the consist may include an energy storage device, which may include electrical storage batteries, capacitors, flywheels, accumulators, or other mechanisms for storing energy. There may be times when it is desirable to change the fuel ratios provided to one or more dual fuel engines at different locations along the train consist in order to increase the amount of power being produced at those locations, and use at least some of that extra power to further charge the energy storage devices.

[0026] The alternators or generators included with each dual fuel-electric power source may be, for example, alternating current (AC) induction generators, permanent-magnet generators, AC synchronous generators, or switched-reluctance generators. In one implementation, each alternator or generator may include multiple pairings of poles, each pairing having three phases arranged on a circumference of a stator to produce an alternating current with a frequency of about 50-60 Hz. Electrical power produced by each alternator may be rectified to convert the power to DC power, and the DC electrical power may be supplied to electrical power bus **180**.

[0027] DC traction motors **20** may be generally operable to receive DC power from electrical power bus **180** that may be pulse width modulated by DC chopper circuits. A DC chopper circuit may include a high speed switch such as an insulated gate bipolar transistor (IGBT) and/or a thyristor, and a free-wheeling diode. The free-wheeling diode may help to eliminate any sudden voltage spikes that may occur across an inductive load such as may be present in traction motor **20** when supply voltage to traction motor **20** is suddenly reduced or removed. AC traction motors may be used in alternative implementations where the DC power from electrical power bus **180** is converted for use by the AC traction motors using inverters. Traction motors **20** may additionally be operable to receive mechanical power from the wheels and axles they are mechanically coupled to and use the mechanical power to generate electrical power in a regenerative braking mode, if desired.

[0028] As traction motors **20** on each locomotive **120**, **124**, smart rail cars **122**, and any auxiliary loads on the locomotives draw more or less electrical power from electrical power bus **180**, the voltage of the electrical power bus may fall or rise proportionally. A controller associated with a locomotive may include a power source control module and associated throttle position sensors and voltage or current sensors. A lead controller on a lead locomotive, or any of the controllers on any of the lead or trailing locomotives may be configured to affect an output of each dual fuel engine and alternator on each locomotive in response to a detected change in electrical characteristics of electrical power bus **180**. As traction motors **20** on any one of the locomotives in the consist draw more power from electrical power bus **180** and the corresponding voltage of the power bus begins to drop below a minimum threshold, any one or more of the controllers may be configured to receive signals from a power bus electrical characteristics sensor indicative of these changes in voltage or current. Upon making a determination that the available voltage has dropped below a minimum desired voltage on electrical power bus **180**, one or more controllers may be configured to transmit control signals to any of the power sources on any of the locomotives in the consist. The control signals may be provided to fuel delivery systems on the locomotives in order to control the fuel ratios of the two or more types of fuel provided to the engines, thereby controlling the amount of power produced by those engines.

[0029] The tasks performed by one or more of controllers **130**, **132**, **134** may also be performed by remote processing devices that are linked through a communications network. In a distributed computing environment, program modules may be located in both local and remote computer storage media including memory storage devices. These local and remote computing environments may be contained entirely within the locomotive, or adjacent locomotives in a consist, or off-board in wayside or dispatch centers where wireless communication may be used. This method and system may be applicable to sharing power and communicating data between any of the linked locomotives **120**, **124**.

[0030] As shown in FIG. **1**, controllers **130**, **132**, **134** may be interconnected by a dedicated serial bus such as the control bus **170**. The control bus **170** may be separate from, or incorporated into a typical communication link between the locomotives such as a standard 27 pin, multi-unit (MU) cable **160**. In some implementations, control of electrical power being shared between locomotives of the consist through electrical power bus **180** may require a more secure protocol than other data being transferred over MU cable **160**. Alternatively or in addition, it may be desired for other reasons to keep control signals related to the transfer of electrical power along electrical power bus **180** separate from the other multiplex control signals being transferred over MU cable **160**.

[0031] Each control computer may be further configured to receive other information or data relevant to the instantaneous operating performance of each locomotive in the consist, such as current fuel levels of each of the types of fuel for each locomotive, ambient conditions at each locomotive, wear levels of various components on each locomotive, and track conditions being experienced by each particular locomotive. One or more controllers may be still further configured to include a system that may provide information on upcoming conditions such as track conditions and grade over the next 50 miles. Such a system may acquire data from GPS receivers and/or maps of the upcoming areas, and provide additional information to a control computer that may be used in determining specific energy management protocols for controlling the fuel ratios provided to various power sources on each of the locomotives.

[0032] The controllers may be configured to control the prime mover power sources and the auxiliary power sources of each locomotive **120**, **124**, and other operating parameters based on input from a vehicle operator or other command control center as well as input received from various sensors. Information may be received from a plurality of engine sensors, fuel level sensors, electrical power output sensors, voltage sensors, current sensors, and/or exhaust aftertreatment (ATS) sensors, and each control computer may be configured to send control signals to a plurality of fuel control actuators, engine actuators, electrical power actuators or controls such as automatic voltage regulators associated with the alternators, traction motor controllers, and/or ATS actuators on each locomotive. As one example, engine sensors and/or ATS sensors may include exhaust gas sensors located in, or coupled with one or more exhaust manifolds for each of one or more engines provided with each locomotive, exhaust temperature sensors located upstream and/or downstream of various emission control devices, and intake regulated emissions level sensors. Various other sensors such as particulate sensors for a diesel particulate filter (DPF), additional pressure, temperature, flow, air/fuel ratio, and alternate regulated emissions sensors may be coupled to various locations on or in the one or more engines provided with each locomotive. As another example, fuel control actuators, engine actuators and/or ATS actuators may include fuel injectors, hydrocarbon (HC) dosing injectors, reductant injectors used in conjunction with a selective catalytic reduction (SCR) process to reduce NOx levels, and throttle or notch controls. Other actuators for controlling mechanical and electrical components or flows, such as a variety of additional valves, voltage regulators, contactor or electrical relay actuators, and current regulators may be coupled to various locations in each of one or more engines, alternators, the electrical power bus, and traction motors associated with each of the locomotives.

[0033] One or more controllers may be further configured to store data and information about each of the power sources on each of the locomotives in a memory device to assist communication with other controllers located onboard the consist. A control computer may also be configured to use this data and information to assist in a determination of which power sources on the consist may be best utilized at any particular time for meeting demands imposed by the addition or removal of rail cars, the terrain over which the train is traveling, the relative quantities of each type of fuel, changes to freight schedules, and other dynamically changing operational parameters. The control computer may also take into consideration a goal to maintain a desired minimum voltage on the electrical power bus. One or more controllers may also store data and information on the electrical power output characteristics of the various alternators or generators, and electrical power consumption characteristics of traction motors **20**, and maintain this information in continually updated logs of the performance characteristics of the various electric drive components on each locomotive.

[0034] Input devices may be located onboard a lead locomotive of the consist, and may include any component or components configured to transmit signals to one or more components of the consist. In some implementations, an input device may include components that an operator can manipulate to indicate whether the operator desires propulsion of the consist by traction motors **20** and, if so, in what direction and with how much power the operator desires traction motors **20** to propel the consist. For example, an input device may include an operator input device with which an operator may indicate a desired consist performance to be received by a lead control computer. In an alternative implementation, an input device may be a computer-based system that may allow the consist to operate automatically without requiring an operator. One or more of the controllers may include circuitry and/or algorithms that enable the one or more controllers to receive and process information in real time from all locomotives, operator inputs, sensors, databases, look-up tables, and/or maps. The controllers may also be configured to determine from this information exactly what power outputs should be requested at any particular time from each of the power sources on each of the locomotives in the consist. Goals may include optimization of fuel efficiency for the entire consist, reduction of emissions, re-allocation of load requirements, equalization of fuel consumption, or precise control of the electrical power outputs of each locomotive as a function of operating parameters, constraints, and objectives. The ability to share power between locomotives may significantly increase the flexibility of the entire system in meeting power demands while improving performance and achieving other desired operating goals.

[0035] To facilitate effective control of the supply of electricity from electrical power bus **180** to traction motors **20** on each locomotive, one or more of controllers **130**, **132**, **134** may be configured to monitor various aspects of engine operation, generator operation, traction motor operation, and/or transmission of electricity within the system. For example, the controllers may monitor engine speed, engine fueling, and/or engine load for their respective engines. Likewise, the controllers may be configured to monitor the voltage, current, frequency, and/or phase of electricity generated by their respective alternators and conveyed over electrical power bus **180**. Additionally, the controllers may be configured to monitor the electricity supplied to and/or consumed by traction motors **20**, a torque output of traction motors **20**, wheel or axle rotational speeds, individual wheel slippage, and/or total tractive forces of each locomotive. The controllers may also employ sensors and/or other suitable mechanisms to monitor the operating parameters. For example, one or more controllers may monitor an actual performance of the consist with one or more sensors, where the actual performance of the consist may include total electrical power consumed by all traction motors **20** during a particular time period or travel distance.

[0036] In situations where fewer than all of the locomotives in the consist are required to meet desired performance characteristics, one or more controllers may be configured to automatically improve fuel efficiency for the consist by transmitting a command to one or more other controllers, instructing the associated one or more locomotives to essentially take itself electrically offline as a result of the command received from a lead control computer. A trailing locomotive may no longer respond to throttle or power commands from a lead control computer, and may instead receive start-up and shut-down commands from an Automatic Engine Start-Stop (AESS) system on the trailing locomotive. In various non-limiting implementations, the AESS system may monitor conditions on the trailing locomotive such as the electrical charge in batteries, air pressure in brake line reservoirs, and engine temperatures. Based on these monitored local conditions, the AESS system may start-up and shut-down the trailing locomotive completely independently from any command received from a lead computer, as independently determined by the AESS system to maintain desired local conditions on the locomotive. The transfer of electrical power over common electrical power bus **180**, which is maintained at or above a set minimum voltage may also enable a locomotive that is electrically offline to continue to draw all of the auxiliary power it may need from electrical power bus **180**.

[0037] One or more controllers **130**, **132**, **134** may be further configured to receive inputs from various engine sensors, electrical sensors, ATS sensors, and locomotive sensors, process the data, and trigger the engine actuators, generator electrical power control actuators, traction motor actuators, ATS actuators, and locomotive actuators in response to the processed input data. The one or more controllers may be configured to take these actions based on instructions, look-up tables, one or more maps, or programmed code or algorithms corresponding to one or more routines. For example, a control computer may be configured to determine a locomotive trip plan including locomotive power outputs and brake settings, engine operating parameters, and the precise levels of electrical power output expected from each generator on each locomotive based on the locomotive operating conditions and current environmental conditions for each locomotive.

[0038] In one example, a control computer may be configured to determine a trip plan including precise electrical power output requirements for each locomotive based on the current voltage and/or current in electrical power bus **180**, individual engine operating conditions, generator electrical power output capabilities, traction motor electrical power requirements, age of the equipment, and operator preferences. Individual locomotives and/or one or more consists of locomotives in a train may be operated in accordance with particular power duty cycles that specify the time spent at each power level or range of total power outputs as a fraction of total time of operation. In various implementations, for example where the dual fuel engines of prime mover power sources **140**, **144**, and auxiliary power sources **150**, **154** are most efficient and achieve best possible brake specific fuel consumption at or near full power, a control computer may provide commands for electrical power output from each of the power sources that will result in the engines on each locomotive operating close to full power for as large a portion of total operating time of each engine as possible. Based on possible differences between the trip plan's time in a particular power duty cycle and a reference duty cycle (such as an EPA duty cycle), one or more controllers may reconfigure the trip plan. For example, based on the differences, a particular control computer may be configured to readjust parameters set during trip planning. These parameters may include electrical power output requirements for each alternator, electrical power consumption or draw by each traction motor **20**, fuel injection settings for each engine, ignition timing, and other engine operating parameters and exhaust aftertreatment parameters. In one example, as an actual duty cycle for one or more of the locomotives starts deviating from a reference duty cycle, thereby possibly leading to increased exhaust emissions or reduced fuel efficiency, a control computer may provide instructions to readjust electrical power output requirements for one or more locomotives for a trip plan that imposes fuel economy and exhaust emissions as constraints. Any one or more of the controllers may be configured to customize a trip plan. The trip plan may be modified during a particular trip based on network data and/or non-network data received from one or more of a smart rail car that has just been connected to the train, an operator, remote dispatch center, onboard sensors including engine operating sensors, electrical sensors, and locomotive sensors, and wayside sensors including hot box detectors, impact detectors, and hot wheel detectors.

[0039] In various alternative implementations, operator input may include a total wattage power output goal, a fuel efficiency goal, an emissions level goal, a tractive power goal, or a performance goal for each of the locomotives or for the consist as a whole. Any one or more of the controllers may be configured to determine the electrical power output desired from each of the power sources on each of the locomotives at any particular time, or over any particular period of time, in order to improve fuel efficiency for the entire consist, reduce emissions, re-allocate load requirements, or otherwise vary the power outputs of each locomotive as a function of operating parameters, constraints, and objectives. This determination may be made by calculating from one or more algorithms, or by reference to a look-up table, one or more maps, or other data obtained over a network or stored in memory.

[0040] FIG. **2** illustrates an exemplary implementation of a method **200** that may be performed by a dual fuel control system included with the consist shown in FIG. **1**. FIG. **2** will be discussed in more detail in the following section to further illustrate the disclosed concepts.

INDUSTRIAL APPLICABILITY

[0041] The disclosed fuel controller may enable operation of dual fuel engines provided on locomotives throughout the consist in ways that may reduce overall operating costs, improve overall fuel economy, reduce emissions, increase engine life, reduce noise, and efficiently and effectively meet a wide range of power demands and tractive efforts called upon under a wide variety of loading conditions experienced by the consist. The fuel controller in accordance with various implementations of this disclosure may receive information from smart rail cars that are attached to the consist. The fuel controller may use this information in real time to adjust fuel ratios of the two or more types of fuel provided to certain engines on the consist. Changes to the fuel ratios provided to the engines may result in changes to the power outputs of the engines, in addition to also affecting levels of emissions produced and other operational parameters. These changes to the outputs of the engines may be desired for any number of reasons. The fuel controller may determine the allocation of the various types of fuel to different engines along the train based upon freight schedules for the train, real time power needs at a particular location along the train, desired emission levels, availability of the different types of fuel, and other factors. The transfer of electrical power from one power generating locomotive to another in the consist along a common electrical power bus running through all of the locomotives may also provide additional flexibility in the operation of the various power sources that would not be available when simply transferring control signals between the locomotives. The disclosed fuel control system and power distribution system may be applicable to any number of vehicles and/or different types of vehicles having electrical power drive in various arrangements. For example, the consist could include additional or fewer locomotives, passenger cars, freight cars, tanker cars, or other rail or non-rail vehicles having electrical power drive.

[0042] At step **202** in the method **200** of FIG. **2**, any one or more of the controllers on a locomotive in a train consist traveling along a rail line may receive one or more signals indicative of a load imposed on the train consist by a rail car attached to the train consist, and a current location of the load along the length of the train consist. The signals may be received from so-called “smart” rail cars. The smart rail cars may be equipped to provide information regarding the location of the rail car, the type of rail car being connected to the train, the type of product being carried by the rail car, what percentage of full load the rail car is currently at or is planned to be at a later time, maintenance information on the rail car, the rolling resistance of the rail car, and other relevant information

[0043] At step **204**, any one or more of the controllers may determine an allocation of the relative amounts of two or more types of fuel that will be provided to an engine based upon the one or more signals indicative of a load imposed on the train consist by a rail car attached to the train consist, and a current location of the load. Smart rail cars may be equipped to store and transmit information regarding the type of rail car, the current and planned products or payload being carried by the rail car, what percentage of full capacity the rail car is at when it is connected to the train consist, information regarding the maintenance that has been performed on the rail car, the rail car’s rolling resistance, and other potentially relevant data.

[0044] At step **206**, any one or more of the controllers may additionally determine the allocation of the relative amounts of the two or more types of fuel by one or more factors selected from a group of factors comprising the type of engine, the energy density of each type of fuel, the efficiency of using each type of fuel, the emissions generated when burning each type of fuel, the cost of each type of fuel, the availability of each type of fuel, the location of the engine in the train consist, and the future predicted loads imposed at different locations in the train consist as a result of the rail cars attached to the consist and the terrain along the rail line.

[0045] At step **208**, any one or more of the controllers may adjust the relative amounts of the two or more types of fuel provided to the engine on the locomotive in the train consist based upon the determined allocation. Various known methods for varying the ratios of the different types of fuels being provided to the engine by fuel delivery systems may be employed. The result of varying the ratios of different types of fuels provided to the engines may include changes in the power output of the engine, changes in the emissions produced by the engine, and changes in the total efficiency of the engine. The changes to the ratios of the different types of fuels may be responsive to many of the performance goals for the train consist. Performance goals may be based on a variety of factors including, but not limited to, reduction in total operating costs, timeliness in meeting freight schedules, improved overall fuel efficiency for the consist, reduced emissions, improved engine life, reduced noise, increased power, reduced drawbar pull, increased traction, or any combination of these and other operational parameters.

[0046] It will be apparent to those skilled in the art that various modifications and variations can be made to the disclosed fuel control system. Other implementation will be apparent to those skilled in the art from consideration of the specification and practice of the disclosed methods. It is intended that the specification and examples be considered as exemplary only, with a true scope being indicated by the following claims and their equivalents.

What is claimed is:

1. A method of controlling the relative amounts of two or more types of fuel provided to an engine on a locomotive in a train consist traveling along a rail line, the method comprising:

receiving one or more signals at a controller on one of the locomotives, with the one or more signals indicative of a current load imposed on the train consist by a rail car attached to the train consist, and a current location of the load;

determining the relative amounts of the two or more types of fuel to provide to an engine operating as a prime mover on the train consist based upon one or more of factors selected from a group of factors comprising the type of engine, the energy density of each type of fuel, the efficiency of using each type of fuel, the emissions generated when burning each type of fuel, the cost of each type of fuel, the availability of each type of fuel, the location of the engine in the train consist, and future predicted loads imposed at different locations in the train consist as a result of one or more rail cars attached to the consist and the terrain along the rail line; and

adjusting the relative amounts of the two or more types of fuel provided to the engine based upon the determination.

2. The method of claim **1**, wherein the engine is one of a plurality of engines, and determining the relative amounts of the two or more types of fuel to provide to an engine further includes determining a different ratio of the two or more types of fuel to provide to a first one of the plurality of engines on a locomotive that is experiencing a larger load than a ratio of the two or more types of fuel to provide to a second one of the plurality of engines on a locomotive that is experiencing a smaller load.

3. The method of claim **1**, wherein receiving one or more signals at a controller on one of the locomotives includes receiving the one or more signals from a smart rail car when the smart rail car is attached to the train consist.

4. The method of claim **3**, wherein receiving the one or more signals from a smart rail car includes receiving a signal indicative of the type of load being carried by the smart rail car.

5. The method of claim **3**, wherein receiving the one or more signals from a smart rail car includes receiving a signal indicative of the weight and location of the load being carried by the smart rail car.

6. The method of claim **1**, wherein determining the relative amounts of the two or more types of fuel includes determining the ratio of diesel fuel to gaseous natural gas fuel.

7. The method of claim **1**, wherein determining the relative amounts of the two or more types of fuel further includes using data from a predetermined trip plan.

8. The method of claim **1**, wherein determining the relative amounts of the two or more types of fuel further includes using at least one of input from an operator onboard one of the locomotives, and input from a dispatch center.

9. The method of claim **2**, wherein the first one of the plurality of engines is located on a locomotive that is traveling uphill.

10. A fuel controller configured to control the relative amounts of two or more types of fuel provided to an engine on a locomotive in a train consist traveling along a rail line, the fuel controller being configured to:

receive one or more signals indicative of a current load imposed on the train consist by a rail car attached to the train consist, and indicative of a current location of the load;

determine an allocation of the relative amounts of the two or more types of fuel provided to the engine based at least in part upon the one or more signals;

additionally determine the allocation of the relative amounts of the two or more types of fuel based at least in part on one or more factors selected from a group of factors comprising the type of engine, the energy density of each type of fuel, the efficiency of using each type of fuel, the emissions generated when burning each type of fuel, the cost of each type of fuel, the availability of each type of fuel, the location of the engine in the train consist, and the future predicted loads imposed at different locations in the train consist as a result of the rail cars attached to the consist and the terrain along the rail line; and

adjust the relative amounts of the two or more types of fuel provided to the engine on the locomotive in the train consist based upon the determined allocation.

11. The fuel controller of claim **10**, wherein the engine is one of a plurality of engines, and the fuel controller is further configured to determine an allocation of the relative amounts of the two or more types of fuel to provide to an engine by determining a different ratio of the two or more types of fuel to provide to a first one of the plurality of engines on a locomotive that is experiencing a larger load than a ratio of the two or more types of fuel to provide to a second one of the plurality of engines on a locomotive that is experiencing a smaller load.

12. The fuel controller of claim **10**, further configured to receive the one or more signals from a smart rail car when the smart rail car is attached to the train consist.

13. The fuel controller of claim **12**, further configured to receive a signal from a smart rail car indicative of the type of load being carried by the smart rail car.

14. The fuel controller of claim **12**, further configured to receive a signal from a smart rail car indicative of a weight and location of the load being carried by the smart rail car.

15. The fuel controller of claim **10**, further configured to determine the relative amounts of the two or more types of fuel by determining the ratio of diesel fuel to gaseous natural gas fuel.

16. The fuel controller of claim **10**, further configured to determine the relative amounts of the two or more types of fuel including using data from a predetermined trip plan.

17. The fuel controller of claim **10**, further configured to determine the relative amounts of the two or more types of fuel including using at least one of input from an operator onboard one of the locomotives, and input from a dispatch center.

18. The fuel controller of claim **11**, wherein the first one of the plurality of engines is located on a locomotive that is traveling uphill.

19. A train consist, comprising:

one or more locomotives with dual fuel control strategies, the one or more locomotives including at least one engine producing a rotational output, an electrical power generator coupled to the rotational output of the engine and configured to generate electrical power when being rotated by the rotational output, and a plurality of electric traction motors driven by electrical power generated by the electrical power generator;

at least one controller configured to receive one or more signals, with the one or more signals indicative of a current load imposed on the train consist by a rail car attached to the train consist when the train consist is traveling along a rail line, and a current location of the load, the at least one controller being further configured to:

determine an allocation of the relative amounts of two or more types of fuel provided to each of the at least one engine based at least in part upon the one or more signals;

additionally determine the allocation based upon one or more factors selected from a group of factors comprising the type of engine, the energy density of each type of fuel, the efficiency of using each type of fuel, the emissions generated when burning each type of fuel, the cost of each type of fuel, the availability of each type of fuel, the location of the at least one engine in the train consist, and the future predicted loads imposed at different locations in the train consist as a result of the rail cars attached to the consist and the terrain along the rail line; and

adjust a ratio of the two or more types of fuel provided to the at least one engine based upon the determined allocation.

20. The train consist of claim **19**, wherein the at least one controller is configured to receive the one or more signals from a smart rail car when the smart rail car is attached to the train consist.

* * * * *