Transitioning to Zero Emission Technology

A guide to ensuring a smooth transition towards future-ready vehicles
Introduction

Planning
Ground zero for successful ZEV technology adoption

Procurement
Transitioning to a Systems Approach

Energy
Keeping ZE Operations Up and Running

Change management
Keeping pace with technological evolution

Conclusion
Zero emission transition: Breaking ground on the road to a cleaner, more efficient future

WSP in action

Key contacts
In the midst of abundant scientific evidence suggesting that carbon emissions are changing our climate in ways that will damage the environment and create economic distress, public demand for a transition to a zero emission (ZE) world is placing the burden on the shoulders of governments and private businesses around the globe to address this crisis by adjusting their operations.

Public and private vehicle fleets find themselves on the front lines of this global transition, due largely to their significance and visibility in the everyday lives of people, the extent of government control in many countries, and the industry’s legacy of fossil fuel consumption. Although governments worldwide are focused on the transit industry, embracing a transition to zero emission vehicles (ZEVs) as part of concerted efforts to meet broader climate change mitigation targets, this focus now extends well beyond public transport fleets. This wider focus requires coordination and collaboration between numerous stakeholders, including regulatory agencies, governments, utilities, manufacturers, service providers, and climate activists, with each stakeholder facing a broad range of new challenges in the increasingly cooperative quest to plan, manage, and finance a large-scale transition to ZE technology.

Hundreds of thousands of ZEVs, both battery electric and fuel cell vehicles, are already in service in cities around the world, transporting millions of passengers and tonnes of freight on a daily basis. Lessons learned from those early adopters go a long way to helping advance the state-of-the-art, which continues to evolve at a rapid pace. The emergence of new and more affordable technologies, refined business models, clearly defined policies and legislation, and flexible financing options together contribute to a set of more comprehensive and implementable options for addressing the many challenges of large-scale ZE technology adoption.
Changing the mechanisms by which various types of vehicle fleets are operated and supported can be challenging given the 24/7 nature of many fleet operations, but transitioning to zero emission can be accomplished with careful planning, a comprehensive approach, and expert advice. While early adopters, including several major metropolitan areas, may have greater resources and capacities to financially assist agencies and operators with their fleet transitions ahead of those in smaller urban and rural markets, the latter will benefit in the long run from greater economies of scale, stabilized pricing, and the availability of tested infrastructure and energy solutions.

Harnessing the collective expertise and experiences of its professionals around the world, WSP has prepared this whitepaper as a blueprint designed to help prepare policy makers and fleet operators for the many challenges ahead, and to highlight areas where expert guidance can help pave the road to a smooth transition. This paper captures the broad complexities of the ZE transition by focusing on four major elements of ZE technology adoption: comprehensive planning, a systems approach to procurement, adapting to new forms of energy provision, and the organizational challenge of change management.
While cities in Asia and Europe have deployed zero emission vehicle (ZEV) technology at a large scale, many other cities, including most North American and Australasian cities, are just entering the critical early planning stage. Accomplishing large-scale adoption requires visionary planning across all phases and all elements of the technology transition. While the challenges of large-scale ZEV adoption may seem overwhelming on the surface, expert guidance and the leveraging of lessons learned from around the world can foster a holistic approach to the transition. Proper planning can thus ensure that preliminary steps are both rational and scalable, guaranteeing the widespread ability to deploy ZEVs at a larger scale further down the road while minimizing disruption of operations and facilities.

From pilot projects through to large-scale deployment, all types of vehicle fleet operators can benefit from field-proven know-how throughout the critical planning stages of their transition to ensure scalability of all system components. In that journey, it is also important to anticipate and overcome the challenges posed by the operational limitations of some ZEVs, the associated infrastructure modifications, changing cost structures, technology transition, and market factors.
Operational Challenges

The transition to ZE technology requires extensive planning for operational changes to ensure that large-scale adoption can address the full spectrum of each agency’s operations. Challenges include charge management at the depot and en-route, as well as route and service block optimization. Current limits on the achievable range of many battery electric ZEVs pose challenges in terms of deciding where to deploy ZEVs, how many ZEVs are needed, and whether and how to extend their range through en-route charging. Charging requirements for these vehicles pose operational challenges to the fluid operation of fleets, both en-route and in the storage depot.

Modelling of ZEV performance on an agency’s services can provide critical information needed to plan where and how battery electric ZEVs can be deployed.

For e-Ferries the planning requires broader discussions with the ferry terminal operator, the transit authority and the power networks.

The range of battery electric vehicles is limited by battery capacity. Batteries are heavy and less energy dense than conventional fuel sources, and the number of batteries on a vehicle may be limited by vehicle weight restrictions.

To mitigate range limitations, fleet operators might consider replacement of conventional buses, trucks, ferries, vans or other fleet vehicles on a higher ratio than a 1:1 basis, purchasing the additional equipment to split up runs into shorter segments.

WSP experts continue to closely monitor progress in the global standardization of plug and charging protocols, noting that standards such as SAE J1772, J3105 continue to emerge as best practices.
Service modelling should consider route topology, stopping patterns, passenger ridership or freight service demands, weather conditions (particularly in cold weather climates), HVAC loads and numerous other factors affecting energy consumption and ZEV maximum range. Vehicle schedules may need to be adjusted to accommodate reduced range or added time may be needed for en-route charging. New operations and maintenance procedures may also be needed at the depot to address new charging procedures, and maintenance staff will require advanced training and new, specialized tools and equipment. Hydrogen fuel cell ZEVs, which have longer range capabilities, may present a viable alternative and/or addition to fleets of battery electric ZEVs. Like batteries, hydrogen fuel cell technologies continue to evolve at a rapid pace. In some cases, fuel cells may be installed on battery electric vehicles as a “range extender”.

**Infrastructure Modifications**

Both battery electric and fuel cell ZEVs require new infrastructure for energy provision and to support charging or fueling. An understanding of infrastructure needs is critical to the planning stage of ZE technology adoption, as the electric power capacity needed for charging battery electric vehicles is not commonly available in existing vehicle storage facilities, nor is the hydrogen supply and fueling infrastructure.

**HVAC loads** have a particularly significant impact on vehicle range, as heating and cooling systems can account for a significant share of energy consumption, compromising range in cold and very hot weather climates. Most ZEVs available today cannot achieve a range comparable to conventionally fueled vehicles.

**Maintenance of electric vehicles** requires specialized tools in order to service the more complex, high-voltage electrical systems not present on conventional fuel vehicles. These systems include conventional battery packs, inverters, electric motors, and more. For e-Ferries the dwell time at the wharf is critical – not just for passenger loading but also for charging, so the e-Ferry pilot needs to know ahead of time that there is power on the ferry terminal and the docking bay is ready for the e-Ferry. This needs a high level of communication and potentially advanced scheduling software (for busy terminals). This may affect the rate of charging selected and the level of emergency power reserve held through the operational shift.
Whether located in trenched exterior bus parking lots, garage floor slabs, or suspended from canopies or roof structures, electrical conduit and cable runs for charging infrastructure need to be designed to limit operational impacts while allowing for effective maintenance, repairs and upgrades.

Reliable access to secure, sustainable, and cost-efficient energy generation and distribution systems is key to the widespread ZE transition for transport systems. Large-scale electrification for vehicle charging facilities inevitably requires new power generation, and sometimes new on-site storage infrastructure. Generation and storage options can be assessed through power system modelling. In the short term, key steps include the identification of existing electrical networks, and planning power grid and generation reinforcements that meet the challenges of the increased power demand. In the long term, a sustainable planning approach will ensure that initial infrastructure will be adaptable to large-scale deployments. It is important for fleet operators to develop strong partnerships with energy providers early, ensuring that the power needs are understood by all parties and are met prior to deployment.

To support an array of charging equipment, the provision of increased electrical service must be supported by on-site substations or transformers. This added equipment, as well as any backup power generation systems or on-site energy storage, can have a significant impact on space requirements at already space-constrained vehicle depots. Additionally, power must be subsequently distributed to each vehicle, requiring elaborate electrical conduit and cable runs for charging infrastructure that must be carefully designed to limit negative impacts on fleet operations and allow for efficient maintenance and repairs.
Hydrogen supply, storage, and fueling for fuel cell ZEVs have their own infrastructure challenges that must be carefully planned for. When planning hydrogen-based ZEV systems, options for the transportation of fuel or, alternatively, on-site hydrogen reformation, as well as storage, must be weighed against space requirements, costs, power requirements, and environmental factors. There may be locations which are naturally pre-disposed to hydrogen deployment due to the proximity of other chemical related industries.

The infrastructure planning process can include the provision of wider power demand studies, asset condition assessments, facility modernization master planning, and other initiatives that help target cost-effective infrastructure optimization. Location planning to align ZEV network infrastructure with existing external power sources, will also play a critical role in minimizing extensive off-site power grid improvement costs that may be required by utility providers. Experts can assist in conducting assessments of existing facilities and operating resources, document unique local operating conditions and requirements, and identify real estate or facility constraints.

![Electrical Infrastructure Diagram](image)

A single ZEV depot charger position (charger, installation, electrical infrastructure) can cost roughly half a million dollars, while off-site power grid improvements can cost millions to bring increased power to a distant site.

Sophisticated modelling tools are available to help transit operators assess the vehicle types, configurations, and charging systems best suited to their operations. WSP has a comprehensive lifecycle cost modelling methodology which can be used to compare different vehicle technology costs. The figure presented shows an example comparison of transit bus lifecycle costs over a 12-year lifecycle.
Lifecycle Cost Analysis

Planning that includes a full lifecycle cost analysis can address the changing cost structures associated with the transition to ZEVs and help agencies plan for capital and operating funding requirements. The capital costs associated with ZEV vehicle fleet implementation are significantly higher than those associated with conventional fuel systems and include major investments in vehicles, batteries, charging systems, electrical infrastructure, energy provision and energy storage. The acquisition of new tools and equipment required for servicing ZEVs also contributes to significant initial capital costs.

In some cases, the higher capital costs may be offset by operating cost savings due to lower electricity prices compared to fuel prices. However, given that the technology is still new and rapidly evolving, few fleets have yet to experience the full long-term lifecycle maintenance costs of ZEVs. Furthermore, energy costs for ZEV operations vary widely by region and can significantly impact whether operating costs increase or decrease. With careful planning, utility rate structures can be leveraged for bulk consumption at cheaper rates.

Like e-Buses, an e-Ferry has a high capital cost but low operational costs. e-Ferry financial business cases vary from e-Bus figures but are generally showing break-even/cost parity between 3 to 10 years depending on locations and associated infrastructure costs (plus factors such as the age of the diesel ferry to be replaced). This is already showing signs of decreasing further as battery costs drop and capacity factors rise. The use of low interest green investment funds may further improve this for specific locations.

Given the large energy needs of an EV fleet it may not be possible to charge during peak load periods. The role of wind and solar derived electricity may be part of the mix with suitable storage infrastructure.

8-year transport costing calculation for an urban bus fleet example, daily distance travelled of 250km, excluding driver costs, in 2018, in Europe (€/km)

Source: Transport & Environment calculation including inputs from CE Delft
In addition, there may be economies of scale and operational benefits for government and private fleet operators from coordinating the transition of different vehicle fleets and types when planning for power and other infrastructure. While many jurisdictions are proceeding with transition of their passenger bus fleets, there are opportunities to consider how infrastructure, procurement strategies and organisational changes can be coordinated across government and with private fleet owners to accelerate or facilitate the ZEV transition of other fleets. A systems approach should also consider a whole-of-government or whole-of-fleet application.

Operators of ZEVs may also consider alternative cost structures, such as battery leases, which transfer risk of what would be higher initial capital costs to ongoing operating costs using expected savings in operations. Long term battery warranties could also be considered for mitigating significant mid-life battery replacement and disposal costs. As the market matures, it is conceivable that leasing options will evolve (as has been seen in the lighter duty car sector) and similarly the 'aftermarket' for life expired batteries (for home energy storage for instance) will also continue to develop.

**Technology Transition**

After decades of fleet operations running on internal combustion engines and fuels, a dramatic shift towards large-scale ZEV systems comes with human considerations as well. As new technologies displace old ones, a variety of stakeholders, including management, drivers, and mechanics, may exhibit cautious reluctance to radical change.

Discussions of transition and phasing strategies are essential to initial planning, ensuring that all stakeholders within operator businesses and regulatory agencies are considered in the process. Implementing change across multiple phases is the most effective way to involve reluctant or skeptical stakeholders in the process, allowing them to test new technologies, witness proof of reliability, provide feedback, and immerse themselves in the process of change.

This approach should include the planning, development and implementation of pilot projects and trials that address not just the technology options, but also the unique limitations and challenges of each fleet's organization and operating conditions. Proper up-front planning will ensure that pilot projects are included in a long-term vision for seamless, phased scalability into large-scale network operations.
**Market Factors**

Commitment to large-scale investment in ZEV fleet ownership and operations systems requires careful study of current, emerging, and forecast market trends. As the ZEV market continues to expand on a global level, the transport industry is witnessing the onset of more competitive pricing for higher quality products. Market prices continue to fall, while battery energy density and capacity is increasing, which is only beginning to relax the current range restrictions for battery electric vehicles.

Practical application of hydrogen technologies at scale are also continuing to provide both challenges and opportunities depending upon the geography, topography and duty cycles associated with a given location.

Diligent monitoring of global market trends for current and emerging technologies and pricing, coupled with expert advice, can help ensure that transit providers capitalize on favorable market trends. Market research and analysis can help guide transit agencies through the technology selection process, ensuring technology acquisitions that are most appropriate given the operational, maintenance and environmental requirements of each provider.

Fleet owners must study applicable ownership regulations, which are often complicated by ZEV purchases. For example, FTA’s “Buy America” rules U.S. transit agencies that will fund its purchases with federal transit grants to procure vehicles that contain a minimum percentage of domestic content, with final assembly occurring in the United States. National and international trade rules could affect procurements of other types of ZEVs.
One of the most critical components of ZEV technology adoption lies in the procurement process for vehicles, charging equipment, and electrical infrastructure. Simultaneous procurement and integration of each of these components creates the need for a broad systems-perspective approach to the procurement process, ensuring interoperability between vehicles, charging systems, and power supplies. In addition, allocation of responsibilities among all stakeholders needs to be addressed early in the process.

Expert analysis of choices made by early ZEV adopters can help other agencies address the unique challenges of ZE systems procurement. Prior to the actual procurement process, the planning process should assess the compatibility between the latest generation zero emission technologies and the agency’s own operational requirements. Such assessments can be refined by the procurement and operational experiences of zero emission pilot projects already underway worldwide, leveraging insights gained from both manufacturers and peer agencies.

**Procurement Challenges**

While ZEVs provide the future promise of lower energy demand and operating costs than conventional vehicles, the transition will require large upfront capital investments for both vehicles and infrastructure.
By identifying and adopting multiple charging standards, such as SAE J1772 or OppCharge, and installing non-proprietary charging technology and management systems at operations and maintenance facilities, fleet owners will increase the number of ZE vehicle and equipment manufacturers they can utilize.

Unlike conventional fuel vehicle procurements, ZEVs form part of an integrated system and can pose unique challenges to transit operators. Vehicles and charging or fueling systems must be fully integrated, compatible, and able to communicate. Additionally, ZEVs can function on multiple propulsion systems, battery types, and fueling systems, each with varying range capabilities. Accordingly, procurement of entirely new infrastructure may be required to accommodate new battery charging systems or fueling stations.

The rapidly evolving nature of batteries and charging systems means that ZE procurement strategies inherently carry higher levels of technical and operational risk than conventional procurements. With multiple competing battery electric vehicle charging methods, charger types, and charging standards, not all manufacturers can support all types of chargers and, conversely, not all chargers will support ZEVs from every manufacturer. For initial ZEV pilot projects and fleet acquisitions, ZEV procurement and charging infrastructure projects must be carefully coordinated to ensure that ordered vehicles will be fully compatible with the installed charging equipment. Chargers must match the vehicle’s charging configuration and on-board system of plug-in ports, rooftop charging bars, and chassis-mounted power receivers.
In order to decrease the risk for technology lock-in effects and create long-term stability for investments, compatibility of multiple systems is of the utmost importance. That being said, varying procurement and ZE technology standards between countries, states, and even cities could further complicate the procurement process.

**Procurement Strategies and Business Models**

A ZE Fleet Conversion Plan can provide a baseline roadmap for managing the transition. Expert guidance can provide stakeholders with unique procurement strategies and business models that account for the agency’s unique specific contracts, timings, and stakeholders, thus mitigating implementation risks and addressing the specific long-term operating requirements of the system. With the emergence of new business models, including leasing options for vehicles, batteries, and chargers that offer greater flexibility, lower upfront costs, and optimize cash flow, each agency’s situation must be uniquely analyzed in order to ensure the best and most sustainable ways of supporting the transition to ZE technology.

Given the rapid evolution of ZE technologies, expert guidance can also help stakeholders negotiate contract provisions \(^{16}\) to help reduce operating and technology risks, which can include mid-life battery system replacement options, and “Evergreen” refresh programs to secure future ZE technology upgrades. Procurement of infrastructure modifications can be more complex and time-consuming than the procurement of vehicles, but experienced professionals are available to assist stakeholders in balancing multiple contracts for vehicles, chargers, facility improvements, and equipment installation. Additionally, experts can assist in identifying which aspects to combine into single procurements and which to procure separately.

The procurement processes and overall strategy must also address the challenges associated with allocation of responsibilities in the ZE transit implementation program. For example, the procurement of the EV fleet can be either the fleet operator or a separate contracting third party.

Creating a common method of contracting enables participants to focus, when necessary, on negotiating only those issues for which a departure from the accepted norm is necessary or desirable. This approach saves considerable time and effort and can be applied to cases where the procurement involves “emerging” technology. One example is the current trend employed by several U.S. bus manufacturers who are offering extended battery and propulsion system warranties of up to 12 years.
However, ZE transitions involving shared depots and other infrastructure can mean a more radical change from existing practices. These situations impose a demand for successful risk- and responsibility allocation between different actors. Questions such as who should own and operate the depot and/or charging infrastructure (an operator, an electric or hydrogen utility, a public sector contracting or financing third party, city or other government agency, etc.) must be thought through and addressed early in the ZE program schedule. Finally, every decision regarding choice of EV’s and charging infrastructure is both constrained by and affects the ownership, dimension and layout of the depots and number and type of fleet that will be affected by the ZE transition.

Leveraging expertise in public-private partnerships (P3) can also assist project stakeholders in weighing the risks and rewards of building such considerations into their procurement strategies. This offers numerous potential advantages to transit operators, including faster implementation, mitigation of technology and operating risks, and reduced operating costs. In its fullest form, a P3 approach can include design-build-operate-and-maintain contracts where a consortium of management and financial consultants, designers, vehicle and systems suppliers, and construction contractors undertake the design, development, and delivery of an entire program, including the sharing of some of the commercial risks.

Organisations undertaking ZEV transitions over a relatively short timeframe (say 15-20 years) should also consider the market implications post-completion of the transition. A sudden reduction in ZEV procurement (the so-called ‘procurement cliff’) could have implications for the viability of OEMs and supporting industry.

Public-private partnerships are common throughout the world, but are still emerging in the U.S. However, several U.S. companies are in the process of developing and commercializing Public-Private Partnership approaches to building, operating, and maintaining charging system infrastructure.
Energy

Keeping ZE Operations Up and Running

One of the most critical components of large-scale ZE technology adoption lies in the ability to secure sufficient, cost-effective, uninterrupted energy to fuel ZE fleets. The coordination of programs for power distribution, capacity enhancement and ZEV procurement is critical while it is recommended that fleet operators develop a closer relationship with power providers than they hitherto had needed to. Before embarking on the ZEV deployment process, numerous energy generation, transmission, and storage options must be taken into consideration in order to find the right balance to manage costs and ensure network stability and reliability.

Expertise derived from the documented successes and challenges of ZE deployments around the world can help guide stakeholders through the multiple components of energy provision, from refueling options, to on-site generation, tariff structuring, microgrid development, and preparing for power disruptions.

Propulsion Types

All ZEVs require refueling, whether powered by electrical energy stored in batteries, or compressed hydrogen stored in tanks. Battery electric vehicles require chargers connected to an electrical energy source, receiving power either directly from the grid or from on-site generators and storage systems. In addition to stationary depot charging, en-route charging can provide off-site power to vehicles on routes that exceed battery range. In such cases, en-route charging can supply the extra power needed to complete longer routes, thus avoiding the need to increase the quantity of vehicles over that needed for conventional fuel operation.

The three electric battery charging technologies currently available are plug-in, conductive and inductive. Plug-in charging can be done with AC or DC power, depending on the vehicle type, and requires that a cord be manually plugged into the vehicle. DC conductive charging is done using an overhead pantograph that automatically connects to charging bars on the roof.

DC inductive charging uses in-ground charging pads, is contactless, and has no moving parts, but requires the largest footprint for supporting equipment and is currently the most expensive of the three options. En-route charging is typically limited to conductive and inductive systems while depot charging has typically been plug-in, though many agencies are considering conductive options due to faster charging rates and the absence of manually operated cords.
Hydrogen opens up new ways of integrating renewable electricity into the energy system and can play an important role in the transition from fossil to renewable fuels. Hydrogen, together with fuel cells, can reduce environmental impacts and render energy usage more efficient.

Additionally, hydrogen can be procured as an existing by-product of other industries. However, hydrogen production is not without challenges.

Hydrogen can be produced from several types of energy sources, with expectations that renewable energy will be used as the primary source for its future production. Hydrogen production by reformation or electrolysis requires electricity. Hydrogen provision may be centralized (hydrogen delivered by truck or pipeline) or decentralized (raw materials delivered to a fueling facility). While centralized hydrogen production can provide high resource efficiency in the production phase, increased distribution costs and energy use can be incurred. Conversely, decentralized production reverses those conditions, with reduced efficiency but lower distribution costs.
**Electric Rate/Tariff Structures**

Operating a ZEV transit system is an energy intensive activity and, as such, energy tariffs play a key role in its profitability. Energy tariffs are aimed at balancing consumption through the day/year in order to match consumption with production and achieve a stable energy system. However, designing a tariff is a complicated task, with multiple factors influencing its structure, including national and global policies and instruments that affect prices for conventional fuels, regulations, politics, consumer behaviour, and future developments. Tariff structures imposed by utilities on energy consumption play a crucial role in managing the cost of ZE transit networks, with underlying price structures that can include use, capacity, and energy-based fees. In order to ensure a sustainable business case for both utility companies and ZE fleet operators, efficient, tailor-made tariffs may be required. Energy-based tariffs, for instance, might be negotiated with incentives for off-peak consumption, resulting in lower costs. Alternatively, demand charges could be negotiated for public transportation providers, resulting in lower costs for operating ZEB facilities. Current and future challenges, like vehicle-to-grid interaction or the lack of maturity of ZE transport, also need to be addressed in the design of new tariffs.

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**Centralized hydrogen production**

| Production of hydrogen | Distribution of hydrogen by for example trucks or pipes | Delivery to the filling station |

**Decentralized hydrogen production**

| Production of the raw material | Distribution of the raw material by for example trucks or pipes | Delivery to the filling station where the hydrogen is produced |
Expertise in regulatory matters and experience in breaking down utility pricing structures can help ZEV fleets stakeholders to design tariffs and to manage energy consumption demand and behaviour more efficiently. In many countries, power markets are highly regulated and as such power rates are likely to be revised to accommodate EVs.

Charge Management

For larger battery electric fleets, agencies will typically deploy an energy management system to monitor and control the charging process. Smart charging management systems can be applied to all charger types and can enable presetting of maximum power usage limits while providing real-time statistics on the status of charging equipment and practices. Expert guidance in the planning and deployment of charge management systems can help ensure a flexible system that enables scalable implementations over multiple phases of ZE fleet growth.

On-site Power Generation

Complete dependency on power from the grid places ZE fleet operations at risk from power outages. While providing double-ended, on-site substations can increase redundancy and resiliency by obtaining redundant feeds from two separate utility circuits, on-site power generation can ensure against large-scale outages. Even without on-site power generation, resiliency can be achieved by connecting to a prioritized power grid along with hospitals and other critical services.

Energy management systems can link together several transit operations systems, including fuel management, yard management, vehicle maintenance tracking software, facility maintenance, and more.
On-site generation can also help mitigate the need for extensive power upgrades and the resulting capital costs of bringing additional power to a depot site. Additionally, any excess in production can be sold back to utility companies to create an additional revenue stream for agencies.

Microgrids

A combination of on-site power generation, emergency generation and in-house energy storage can produce a microgrid capable of charging ZEVs. A variety of sophisticated microgrid blueprints are emerging, allowing energy sources, such as solar power, to generate charging capabilities without connecting to the existing grid.

Experts engaged in research on power generation solutions and emerging technologies can help transit providers determine the right course of action for leveraging the potential of microgrids. Pilot projects in Denmark, the Netherlands, the UK, and the US are being closely monitored, with grid operators investing in battery energy storage projects that could provide additional value in terms of their grid balancing capabilities.

Some emergency generation may have an opportunity to convert from fossil based diesel to bio-diesel. This may require improvements to sensors and ECU but in the process may reduce the carbon footprint without major equipment replacement.
Power Contingency Plans

Power outages caused by extreme weather, natural disasters, or technical failures must also be considered, requiring thorough and robust contingency plans designed to limit service interruptions and ensure ongoing maintenance of operations. Fleet operators and cities must also reconsider disaster planning and evacuation to accommodate vehicle range, infrastructure, and refueling times characteristic of ZEV technologies.

Experienced professionals can assist stakeholders in designing and implementing region-specific safety and contingency strategies to prepare for such occurrences. Strategies can include redundancy of microgrids and other sources of on-site power generation that address the inherent risks of power outages and help minimize network interruptions.

Strategic placement of distributed and redundant infrastructure to support operations during local power outages is among the most effective contingency strategies being deployed to support ZEB refueling.
Keeping pace with technological evolution

Around the world, private companies and public agencies alike are incorporating emission reduction into their investment and business strategies, laying foundations for a future targeting new efficiency opportunities, resilient new infrastructure, and the leveraging of sustainable economic development possibilities. Transitioning to a world of zero emission will affect all aspects of the transport industry, and the willingness of fleet operators to develop proactive measures and to implement innovative solutions is essential if providers are to keep pace with evolving stakeholder expectations. As part of that process, fleet owners must recognize that managing organizational change is a key component of any strategy to advance zero emission technology adoption.

Transitioning from fossil fuels to ZE technology will inevitably introduce new market players in a variety of sectors and capacities, but transportation organizations must ensure that they themselves acquire the technical knowledge and skills that are relevant to understanding, operating, maintaining, and troubleshooting their ZE fleets. This will require appropriate training at all levels of the organization, including management, service planners and schedulers, operations supervisors and dispatchers, drivers and mechanics, and facility operations and maintenance staff.

Many companies with business strategies espousing emission reduction targets and conversion to renewable energy are demanding change throughout their supply chains. As organizations effect change, they communicate to stakeholders, including investors, customers, and policymakers, that a future powered by renewable energy is viable.
Service Planning and Scheduling

Until now, service planners and schedulers have focused on optimizing vehicle and driver utilization with little need to consider limitations on vehicle range and fueling requirements. However, with most currently available ZE technologies, vehicle range limitations need to be considered, as well as scheduling times for charging batteries, either en-route between trips, or in the depot during night time or midday periods when service may be reduced. As ZEVs begin to represent a larger share of fleets, range limitations could require larger fleets to meet existing service needs. Modelling of the capabilities of the latest ZEVs on an agency’s route network may be needed to inform vehicle procurement decisions, and advances in scheduling software are emerging to assist in building schedules that take range limitations and charging requirements into account. Supervisors and dispatchers will also need to be aware of range limitations and charging requirements when assigning ZEVs to the fleet’s services.

Operations and Maintenance Training

The amount of training that is needed for the transition to ZE fleets will depend on staff familiarity with the technology. Driver training on ZEV regenerative braking and acceleration characteristics is needed in order to achieve expected operational efficiencies, as well as training in en-route charging protocols. Additionally, facility staff training must focus on charging and fueling requirements, developing a thorough understanding of depot charging protocols, and proper overnight parking configurations and procedures. While the amount of maintenance training needed will depend on the particular technologies adopted, at a minimum this will require knowledge and skillsets relating to electric traction motors, inverters, batteries, and high voltage, as well as electrical safety training. Proper training can ensure that all required high voltage safety procedures, personal protective equipment (PPE), and specialized tools are in place.

Expert guidance can assist with development of new standardized maintenance procedures, as well as standardized operating procedures and training for battery charging or hydrogen fueling. Additionally, training for emergency responders and utility workers should be provided to ensure that, in the event of an accident, potential high voltage and chemical hazard factors are accounted for.
Consultant expertise can be leveraged during the RFP and contract negotiation processes for vehicle procurement, assisting fleet operators in establishing requirements for OEM-provided training. Further guidance can be provided during development of comprehensive training programs, including secondary training programs that leverage the newly acquired knowledge and skills of key personnel in order to conduct further training of mechanics and other labour resources internally.

Labour agreements and staffing levels

The skillsets required to manage and maintain a fleet of ZEVs could well be very different from those required for conventional fuel vehicles. Managing the transition to ZEVs will require labour negotiations, as changes associated with ZEV adoption will inevitably alter the scope of work assigned to drivers, mechanics, and facility staff. Working with high voltage equipment, participating in newly required training programs, attaining new certifications, and subsequent new staff classifications will all require adjustments to existing labour agreements. Additionally, as ZE fleets expand, staffing levels, in conjunction with changing labour requirements, must be evaluated to ensure appropriate levels of coverage.

While OEMs provide related operating and maintenance manuals, additional training can be procured through third-party institutions. Required training should focus on zero emission-specific electrical systems, as other standard electrical features are similar to existing diesel fleet counterparts.
Expertise in labour management negotiations can assist management teams in conducting thorough assessments of existing collective agreements in order to clearly determine the impacts of adopting ZE technology. Additional assistance can be provided for developing new internal labour classifications, as well as in the restructuring of labour resource requirements in accordance with fleet expansion and future ZE technology adoption strategies.

Planning for change

Consulting with industry experts in zero emission technology can help fleet operators develop a change management process. Strategic advice and thorough assessments of organizational gaps can help fleet operators ensure an efficient and effective transition. Expertise in negotiations with external stakeholders can also help facilitate a smooth transition, particularly with respect to utilities who must be part of the conversation. Consultants can assist organizations in orchestrating and implementing internal shifts in corporate culture, policies, and practices, which is a critical step for facilitating the transition for existing management and staff. Having a change management plan in place that incorporates all facets of the transition to ZEVs will streamline the process and overcome many of the potential obstacles to change.

The shift to ZEVs can mean structural change to funding levels and balances, such as the relative scales of capital and operating budgets, that can be challenging for fleet owners to navigate. Particularly in bus fleets, where in some jurisdictions government-owned services have been fully or partially franchised, fleet and depot ownership models can add layers to the funding responsibilities required for ZEV transition, and the complexity of the process. But the challenges of structural change to funding levels and balances is not only limited to fleet owners; rather it is something that needs to be mitigated already in the procurement phase. This can present a challenge for the contracting party, especially when deciding on what to include and not to include in the contract. Additionally, this could also affect how to structure the compensation model which sets the prerequisites for corresponding business models of the fleet owners. WSP experts can help to develop robust business cases that can make the case for ZEV transition and highlight the key data points that support funding requirements and support the case for change.

In a rapidly evolving discipline, regular updates to the economic, financial and business case aspects of the ZEV transition may be required.
Conclusion

Zero emission transition: Breaking ground on the road to a cleaner, more efficient future

Through a future-ready planning approach, transportation fleets, regardless of the services they provide, can help address environmental concerns and move towards a bright future of greater operational efficiency and continued benefits to people and communities whose world of mobility and fulfillment depends on their services. The process of working towards a large-scale ZE transition today will also help prepare organizations internally for the implementation of future innovations further down the road that will continue to drive the leading edge of transportation.

As years of investment in research and development of ZEVs and supporting infrastructure continues to bear fruit, more affordable and accessible technologies are entering the market on an increasingly frequent basis. For example, as battery life increases, and battery size and weight decreases, vehicle fleets are benefitting from increasingly cost-effective options capable of covering the range and scope of their network operations. A smooth transition to zero emission operations also relies heavily on the advancements of external players, and that process will require close collaboration in order to ensure advancement of all facets relating to zero emission operations.

Regardless of the transportation mode in which they operate, fleets’ adoption of ZEVs can be community-building tools that influence investment decisions and fosters economic development and revitalization.

The pace at which change is occurring in all transportation industries leaves very little room for procrastination. To keep pace, proactive measures must be taken across the entire landscape, requiring new levels of cooperation, revamped business models, industrial innovation, focused research, experimentation and short- and long-range planning.
The business case for ZE technology adoption continues to grow with every advancement, and its future opens the door to extensive operational benefits over the longer term, as the cost of purchasing, operating, and maintaining ZEVs eventually decreases. ZE fleets offer sustainable solutions, including increased energy efficiency, long-term economic benefits, and carbon emission reductions that allow the planet to breathe easier.

WSP is a global leader in low and zero emission vehicles and has assisted both large and small fleets on all continents with optimizing operations and adopting new technologies. Our expertise, accrued over many years, has fostered a holistic approach to fleet planning, design, and management, combining depth of experience with the adaptability and responsiveness required to guide government and private sector stakeholders through challenging programs.

WSP experts can guide fleets through the full lifecycle of ZE transition, from developing short-term pilots and long-term transition plans, to designing procurement strategies, and recommending steps for large-scale implementation. Our expertise extends to the energy sector, with professionals around the globe involved in research and development of innovative solutions for our clients.

We also possess the experience and know-how to facilitate stakeholder relations, and to facilitate shifts in organizational culture in order to ensure a smooth transition at all levels.

The road to tomorrow begins today, and WSP has the experience and expertise to accompany you along every step of your journey.

In Memoriam and Dedication
Jim Wensley
1959-2021

This white paper is dedicated to its lead author, who was a great planner, colleague, and friend. WSP’s deepest sympathies are extended to Jim’s family and loved ones. Because he firmly believed in a sustainable future for our world, this white paper is a tribute to his life’s work.
WSP
in action
Working on behalf of the Los Angeles Metropolitan Transportation Authority (Metro) and in joint venture with STV, WSP is creating an analysis of Metro’s network of 165 bus and bus rapid transit routes and 11 maintenance facilities, making recommendations for the procurement of a new bus fleet, and performing conceptual designs of the modifications at facilities necessary to support the fleet. The master plan will provide a year-by-year schedule that will help Metro achieve a 100-percent zero-emission bus (ZEB) fleet by their target of 2035 (five years before the State’s mandate). It includes also recommendations regarding training, safety planning, disaster planning, and cyber security for the bus fleet.

It is the largest such commitment to a ZEB fleet in the U.S., and one of the largest in the world.

As the master plan creates a time table for transition to a fully electric fleet, planners are also evaluating existing routes to determine if they need to be modified to accommodate these vehicles. One of the key challenges with the master plan centers around the battery charging capabilities for each ZEB. To meet current and future needs, the master plan also assesses the feasibility of using existing passenger transfer and layover facilities as en-route charging locations.

Advances in smart technology could also help networks like Metro’s evolve and adapt into a more efficient and responsive system for commuters. For example, the ability for the vehicles to be monitored for passenger information, real time dynamic monitoring and vehicle-to-vehicle technology are working their way into these buses today; these and other systems will be better integrated to manage energy consumption in the future.
Transportation is responsible for half of all carbon emissions in King County. King County Metro is responding to this challenge in a multitude of ways. An important first step in achieving the agency’s climate goals has been to dedicate resources and leverage federal funds for electric bus fleet purchases. In April 2016, the King County Council passed Motion 14633, which took these initial steps further by directing King County Metro to develop and transmit a feasibility report that identifies and analyzes strategies for and barriers to achieving a carbon-neutral or zero emission vehicle fleet by 2040. Metro received a USD 3.3 million Low or No Emission Vehicle Deployment Program (LoNo) grant from Federal Transit Administration (FTA) that has helped to fund the purchase of eight additional battery electric vehicles and associated charging infrastructure.

As a subconsultant to Metro’s consultant team, WSP provided technical assistance to develop short- and long-term plans for transition to a zero emission fleet. The analysis also informed Metro’s next revision to its Long-Range Transit Plan.

Keeping the Future Ready approach in mind, the analysis addressed how current and future technology improvements are likely to affect issues of cost, range, battery life, and types of vehicles available. It also covered all aspects of charging technology and the impact on service characteristics, life cycle cost, and procurement issues, including an analysis of en-route and depot charging technologies. Finally, it helped identify and evaluate the significance of technology, policy, market and commercial barriers to deployment of advanced vehicle designs, including advanced propulsion technology.
In 2017, WSP was retained by Global Sustainable Electricity Partnership (GSEP) to conduct a feasibility study for introducing electrified urban public transit via battery electric buses (BEBs) in Lima, Peru. The project objective was to study the feasibility of fully incorporating a BEB into a public transit line. WSP analyzed and evaluated the potential for piloting electric buses using its proprietary simulation Battery Optimization and Lifecycle Tool (BOLT). WSP also developed a Total Lifecycle Cost for electric buses comparing the benefits of maintenance and capital costs over the complete lifecycle of the vehicle along with considering socioeconomic and environmental benefits such as emissions and noise reduction.

Furthermore, WSP developed a BEB technical specification which was both performance-based and compliant to local Protransporte vehicle requirements. WSP also provided support with the deployment of a quality assurance inspector to the bus manufacturing facility in China.

To coincide with the launch of the BEB on Route 201 along the Javier Pardo Corridor, WSP developed a pilot strategy to collect data over the 2-year pilot period and feed this data into a Replicability Report to determine the scalability of further BEB adoption. Data collection includes vehicle maintenance records, real-time energy consumption, performance monitoring as well as driver and customer feedback.

WSP has also performed a site assessment of the Patio where the BEB will be parked and charged in order to bring forth recommendations for improving safety and operational aspects of the pilot. Leading up to the launch, WSP provided a three-day training segment on-site in Lima to local operators and stakeholders of the project. These covered lessons learned from BEB deployments around the globe as well as diving into implications for BEB maintenance, safety, charging infrastructure and impact to operations.
In 2018, WSP was mandated by Östgötatrafiken, the public transport agency in Östergötland province, Sweden, to investigate how electrification of bus traffic in the city of Linköping could be achieved, which would serve as a knowledge base for future agency decisions. WSP approached the task in three phases, beginning with a detailed investigation of multiple scenarios for the introduction of electric buses. The second phase focused on how further electrification could be achieved in relation to the aforementioned scenarios, while the final phase studied procurement issues that would need to be addressed ahead of introducing electric buses during the next contract period. Within that framework, WSP conducted literature reviews and interviews with market participants and key stakeholders, and held workshops and meetings with Östgötatrafiken.

WSP’s investigation concluded that electrification in Linköping could be achieved without incurring significantly higher costs, and also identified the potential risks of such a transition. WSP also determined that the city’s electricity grid would be capable of handling the additional energy demands of electric bus operations. In summary, WSP’s report provided an impact analysis of the cost of introduction, environmental impacts, energy usage, and impacts on the electricity grid.
As part of an initiative to accelerate transition to ZE transport, WSP was commissioned by several industry players, including Vattenfall, Ellevio, Volkswagen, and Scania, to develop an action plan for the electrification of all mobility in the Swedish capital of Stockholm. The ambitious plan covers all types of mobility, including private cars, commercial transport, and heavy equipment.

In collaboration with various stakeholders, the WSP team mapped out future challenges and opportunities related to transition to a fully-electrified transport system, with economic, environmental, and social sustainability factors forming the foundations of the plan’s activities and milestones.

Several innovative solutions were proposed for addressing the groundbreaking challenge of electrifying all transportation within a city center as large as Stockholm, including assessments of how logistic centers could be used to transfer goods from conventional vehicles to smaller electric vehicles. The action plan identified necessary legislative and regulatory changes, proposed innovations, and outlined the type of infrastructure that the endeavor would require. Additionally, WSP identified consequences that various sectors, and society itself, will likely encounter in respect to implementation of the recommended steps of the action plan.

Leveraging global expertise in smart cities, sustainability, and much more, WSP professionals from Sweden and around the world collaborated on this project to provide a clear understanding of the complexity of future challenges, and to propose new future-ready ideas for capitalizing on the endless possibilities that current and future technology can provide.
WSP analyzed and provided a custom output for Auckland Transport and Vector Lines Distribution Company to accurately predict the impact of bus electrification project as Auckland City pursued its program of decarbonizing public transport, using out Battery Optimisation and Lifecycle Tool (BOLT) which was checked against a number of pilot buses both in NZ and other countries.

The projected energy demand was shown to be influenced by a number of key factors including the size of the future bus fleet, the bus technology adopted across the network, the location of the depots and the charging regime deployed.

Given the dynamic growth of Auckland, ongoing improvements to the transit system and the rapid pace of technological change, the forecast had to be dynamic and WSP created a custom tool called BOLT - Post Processing (BOLT-PP) which enabled Vector and AT to change assumptions about bus sizes, battery degradation and charging methodology to visualize the resultant impact on the bus routes completed, the number of buses required and the energy demand (including peak maximum demands and its timing.) A major advantage of this approach is that it readily enables an understanding of the sensitivity of the projected energy demands to change in the stated assumptions.

We will work closely with Auckland Transport to assess the size, location and type of the future bus fleet.

For Auckland Transport, this project was key to setting the forward map of actions required prior to the start of the next round of bus procurement, which was only 42 months away. For Vector, the bus fleets represent a new major electrical energy customer with substantial change to bus depot demand. The load and peak energy profile will potentially move the bus system into a similar category as the electric rail. The key differences were considered to be the variability of the demand and current low conventional resilience of the industrial areas where the bus depots were located.

Feedback from Vector indicated that BOLT-PP saved them weeks of work forecasting various scenarios of adoption as the tool simplified the process and covered the required options.
In Denmark, the first 100% electric ferry is sailing between the islands of Ærø and Als. Named Ellen, the e-ferry saves about 2,520 tonnes of CO2 each year compared to its predecessor.

WSP was the lead engineer for the civil works for the ports of Ærø and Als, while also designing a third port in Faaborg on the island of Funen to prepare it for the ferry. The mandate mainly includes sheet piling and anchoring, landfill, ferry ramps, foundations, fendering, automated mooring, and cable ducks.

On Ærø, six 2 MW wind turbines produce on average 125% - 140% of the island's annual electricity consumption. This production leaves plenty of surplus energy for Ellen. The operation of the ferry is therefore CO2 neutral. In addition to maintaining a high service level, Ellen also sails faster than the old diesel ferry it replaces.

When it arrives in port, the electric ferry must connect very quickly to the electric system to recharge its batteries. This was one of the challenges in redesigning the ports for the new ferry. The charger is located on the ramp, so it follows the ferry's movements in the dock, thereby providing a very reliable charging connection.

The overall savings are significant because of the very low operating costs. Slightly higher investment costs turn into savings within 4 to 8 years of operations, generating significant savings for the remainder of the ferry's lifetime.

The project has received funding from the European Union’s Horizon 2020 program and has garnered international media attention. The e-ferry project was also received the Danish Design Award 2020 and the European environmental award, European Solar Award.
The ACT Government has committed to reduce the Territory’s CO2 emissions to net zero by 2045 and reduce emissions by 33% by 2025 from 2019 levels. The bus fleet generates around 50% of Government emissions, so the transition will have a substantial impact on this target.

WSP delivered Phase 1 of the transition to a zero-emission bus fleet, which focused on scoping, feasibility and transition planning. The emphasis was on identifying, evaluating and costing the preferred transition scenario(s), and developing the associated transition and implementation plan.

WSP leveraged our international experience and technical expertise to deliver this project.

We used WSP’s proprietary BOLT (Battery Optimisation Lifecycle Tool) to model operations using a mix of zero-emission vehicle types. The analysis enabled us to understand the power requirements and optimise schedules, routes, fleet sizes and charging infrastructure for battery-electric buses.

We worked collaboratively with Transport Canberra to provide a holistic guide towards achieving a zero-emission fleet by 2040, including considerations for: depots and infrastructure planning; fleet procurement; costings; energy considerations and workforce training.

WSP is currently delivering Phase 2 of the transition plan. This involves more detailed planning covering depot design considerations, an energy strategy, fleet and charger specifications and further network planning using BOLT.
WSP worked with Tranzit Group to install a 450kWh opportunity (fast) charger using a pantograph system in Island Bay, Wellington. The pantograph arrangement was chosen to make use of the fast charger, considering that a plug-in solution was not available for such high-speed charging. High speed charging reduces the number of batteries required as the bus is regularly charged throughout the day. This results in a greater number of passengers being carried, optimizing the bus for public transport use. Common practice overseas is to place the pantograph on the roof of the bus, however on a double deck, this would have resulted in the bus becoming overheight for New Zealand roads. Tranzit utilised their engineer’s specialist skills and reassembled the pantograph in their workshop to be mounted on the rear of the bus, eliminating the overheight issue. This is believed to be a world first.

The power demand required a new substation as the electrical distribution in the area was already at full capacity. A new substation was installed by Wellington Electricity and WSP ensured the charger was modified to comply with WorkSafe requirements and the earthing requirements in NZ (which differ from Germany).

WSP also successfully completed the earthing study (step and touch potential) to ensure that a wet, bare foot child “hugging” the charger’s casing (because it is warm!) was kept safe in the unlikely event of an internal fault or a near-by lightning strike.

The project has proved successful with 10 double decker electric buses operating for 20 hours a day, with another 31 on order to operate in Wellington.
WSP has performed a study on behalf of the Gothenburg Business Region and the EU project Periscope (Platform for Expanding Regional Innovation SCOPE for blue growth). The aim was to map how cities and regions in Europe, primarily outside Sweden, view and relate to the developments within the field of electrification of leisure boats. The global developments in the field were also considered. Furthermore, the study highlights which topics different stakeholders could collaborate on when it comes to enabling sustainable development for leisure boats and leisure marinas in Europe.

The results of the study will support strategic decisions on the current readjustment in the field of leisure boat electrification in the region of Gothenburg as well as in Europe. The study will serve as a strategic basis for upcoming blue growth grants and fund application procedures at the regional, national or European level.

The study was performed as a literature review, interviews with relevant stakeholders and an international workshop to obtain a basis for a future scenario regarding the development of the situation in Europe in relation to Sweden.
WSP supported a leading global ecommerce business in delivering on its ambitions to be carbon neutral by 2040, by transitioning its UK fleet of delivery vehicles over to electric vehicles.

WSP provided Project and Commercial Services over an 8 month programme in 2020, and were responsible for managing and overseeing the delivery of over 1,600 electric vehicle chargers at 17 distribution sites across the breadth of the UK and Ireland.

This was a pathfinder project for the client, being the first of its kind they had undertaken, so they were seeking to develop an understanding of which would be the most suitable charging infrastructure technology and deployment option, as well as procurement support for the preferred solutions.

The project entailed the consolidation of existing information to enable definitive plans to be developed. A key consideration for the team was to ensure that the charge points were futureproofed and scalable, so additional chargers could be added over time in line with increasing demand, and managed efficiently to ensure optimised charging schedules.

The charge points were to be deployed on live sites, so careful planning was entailed to minimise disruptions to the core business activities. The team were also responsible for the resolution of Town Planning aspects of the deployments.

A key feature of the project was engaging with the range of stakeholders to ensure timely delivery. A key stakeholder were the DNOs, who are responsible for providing the electrical supply into the sites, given the significant demand as the number of EVs on each site increases over time.

The project resulted in the successful deployment of the charge points, enabling the organisation to take an important step towards its ambitions to be carbon neutral.
Transport is responsible for about one-fifth of Finland’s greenhouse gas emissions. Road transport is responsible for almost 95% of these emissions. The path to a carbon-neutral Finland requires strong investments in the development of public transport and its propulsion choices. Most of Finland’s urban public transport is concentrated in the Helsinki region, where the Helsinki Region Transport (HSL) is responsible for organizing public transport. HSL’s goal is to reduce local emissions that affect air quality and CO2 emissions more than 90% by 2025. This will be achieved by requiring the use of renewable biofuels from all diesel and gas buses, and by increasing the number of electric buses. Currently, about 50 electric buses operate in the Helsinki region, and this number will increase to about 175 electric buses this year (2021). HSL’s target for the number of electric buses in 2025 is 30% of all HSL’s bus traffic, a total of about 400 electric buses in circulation in 2025.

WSP has helped HSL on its path to increase carbon-neutrality in public transport. As part of its work, WSP has developed an overview of electric buses charging in the Helsinki region to serve the future tendering and traffic planning. In-depth stakeholder interviews were conducted with cities, bus operators, charging operators, electric grid companies and equipment suppliers. Based on these interviews and as an expert assessment, WSP assessed the pros and cons of electric buses charging methods, their suitability for different locations in the Helsinki region, and a reasoned proposal for organizing the bus charging at various locations. In addition, WSP made a long-term assessment of the traffic volume of electric buses and the need for charging during operations in the Helsinki region, and assessed the effects of electric buses and charging during operations on the traffic capacity of bus terminals.
In 2015, we compared different propulsion modes used by public transport in the Lahti region and the suitability of propulsion modes were investigated in more detail. In addition, a basic plan for building a propulsion system was developed. The relevance of the system for other commercial vehicles was also evaluated.

In the 2019 updated propulsion report, the suitability of different propulsion engines (diesel, biodiesel, electricity, biogas, hybrid) for urban public transport in general were examined, and a comparison of different propulsion engines was made in regard to GHG emissions and total costs. We determined the availability of equipment and propulsion modes now and in the future, as well as the necessary investments in infrastructure, for the various propulsion options. In addition, we clarified the general practice of public transport operator roles in different propulsion options and the cost allocation to different parties. The impact of the EU Clean and Energy Efficient Vehicles Directive on public transport in the Lahti region was also examined. Furthermore, the possibilities for utilizing the Energy Agency’s transport infrastructure support were examined. A presentation of the bidding sites for the situation of the new trunk line was integrated in the report. Finally, a roadmap and recommendations for the utilization of new driving forces in public transport in the Lahti region were submitted.

Lahti is the European Green Capital 2021, aspiring to highlight the best European environmental solutions, support the climate goals of Lahti and the whole Finland and start ambitious cooperation projects.
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