BUS MOTIVE POWER OPTIONS – Comparison of various types

This table provides an outline of the main types of motive power that can be used in buses intended for use in city transit use generally with a focus on Wellington. Petrol is excluded as it tends to be used in smaller passenger vehicles only. Costs of buses is indicative only.

Motive power category	**System name / known as**	**Technology status/ Cost per bus**	**Emissions**	**Advantages**	**Disadvantages**
Diesel Bus Diesel engine - direct drive	Diesel bus (a **non-electric** option)	Mature & proven /$400k	High	- Cheaper capital costs - Operating costs dependent on price of diesel. - Maintenance cost higher than electric motors. - Readily available in marketplace - 15 year lifetime expectancy	- High emissions - Noise
Hybrid Bus Battery driven electric – Diesel engine charges battery or provides an additional direct drive.	Hybrid bus (a **partial electric** option)	Developing /$650	Moderate, compared to diesel bus	- Use of battery designed to cut down diesel fuel use - Reduces fuel use and emissions - Drive wheel located electric motors ensures lighter mechanical components (if provided). - Potentially smaller diesel motor if for generator only.	- Higher capital cost ($650k) - Weight of batteries reduces passenger capacity - Reliability of components unknown - Battery costs
Hybrid Turbine Bus Battery with on-board Turbine battery charger (Wrightspeed)	Hybrid bus (a **partial electric** option)	Early stages of development for urban transport. **Costs ???**	Moderate to Low (depending of fuel used for turbine generator, and use of charging stations)	- Potentially lower emissions compared to any diesel option. - Turbine use can be reduced if battery charging stations used.	- Technology in early stages of use. - Costs not quantified for new or existing vehicle modifications - Turbines usually lower efficiency than new diesels - Turbines may have high operating costs. - Additional layover time for battery charging may be required? - Weight of additional batteries (if needed) may reduce passenger capacity?

<u>Electric Battery Bus</u> Battery only - 100% re-charging from grid power supply	Battery bus (an **all electric** option)	Developing /$900k Early stages in Europe (1st big order for 50 for London due to start late 2016)	Zero or Low emissions	- Zero tailpipe emissions - Low total emissions (depending on power grid renewable %) - Lower maintenance costs (less moving parts) but this is off-set by need to replace batteries periodically. - Electric motors <u>if located</u> in each drive wheel may reduce overall weight	-Considerably higher purchase costs (say $900k) - Distance run between battery re-charge stops is limited, so longer running times may require greater battery capacity. - Weight of batteries may reduce passenger capacity. - Higher operating costs due to need for periodic replacement of batteries. - Needs suitable charging systems located at depots and some bus stations - Additional layover time for battery charging may be required – additional vehicles may be required to cover layover times required for battery charging
<u>Trolleybus</u> Power from overhead wires (with on-board battery for short off-wire operation)	Trolleybus / (an **all electric** option)	Mature / proven. Extended distance battery use under development	Zero tailpipe or Low total from grid	- Zero tailpipe emissions - Low total emissions (depending on power grid renewable %) - 20-25 year lifetime expectancy - Cheapest long term operating costs particularly for high density routes. - No layover time for battery charging necessary (battery recharged from overhead).	- Fixed overhead wires and power supply infrastructure - Higher capital costs - New buses expensive

Notes re Batteries. Battery technology for heavy commercial vehicles is advancing but all types have limitations on life expectancy. 5-7 years is often claimed in city use but operating experience shows that practically this may not be realistic at this stage, particularly for intensive service use.

Battery life is generally dependent on;

- Charging rates – quicker or fast charging on a continued basis can limit the life
- Depth of discharge – regular deep discharging to use up the bulk of battery capacity reduces life considerably
- Operating environment – heat and vibration can also limit life.