High performance and low CO_2 from a Flybrid® mechanical kinetic energy recovery system

LCV 2015 - Energy Storage and Electric Machines

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TOROTRAK

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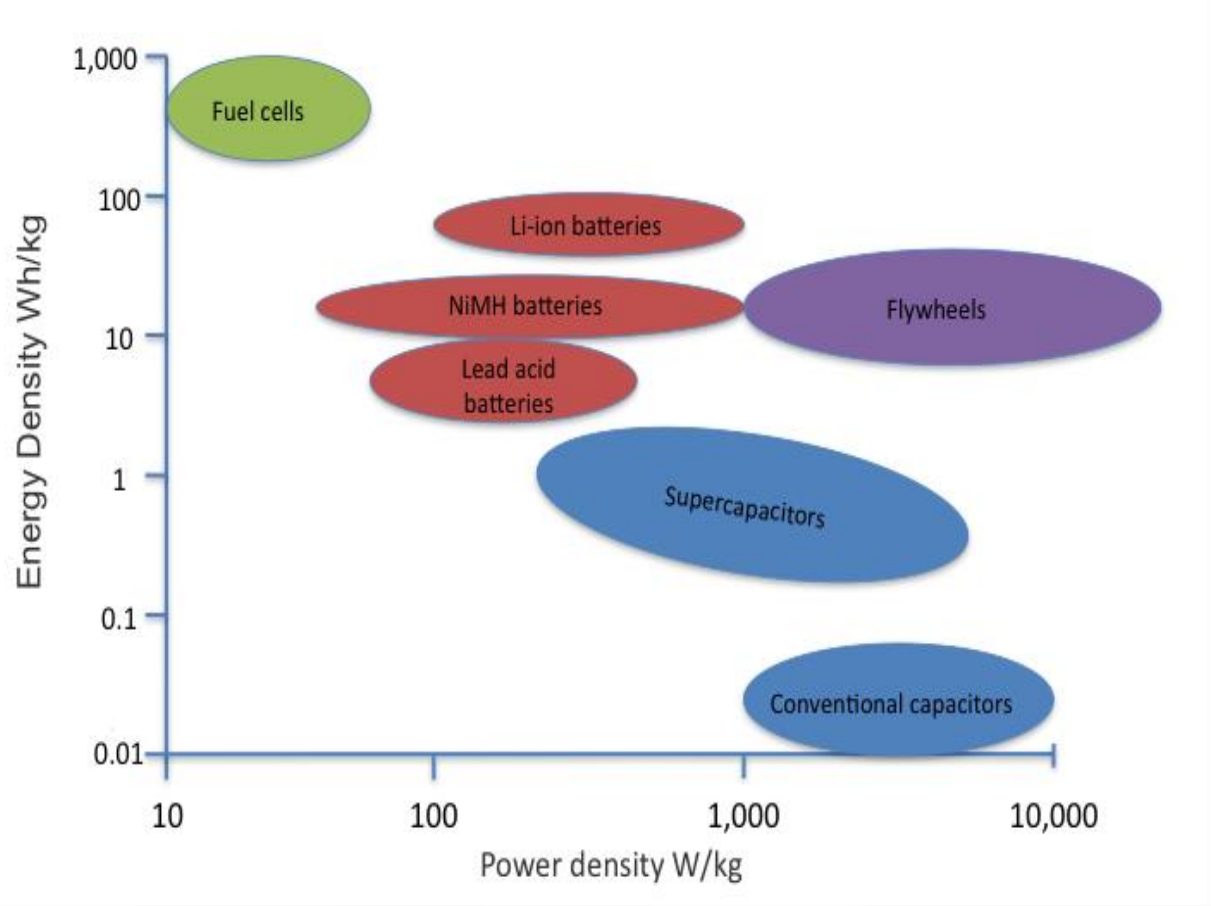
Summary of contents

- Overview of Hybrids
- Principles of Flybrid Flywheel Technology
- Performance and Durability
- Exploitation for Performance Passenger Cars
- Conclusions

Overview

Overview of Hybrids



- Different Technologies have a variety of Power and Energy Densities
- Flywheels have high power density and competitive Energy Density

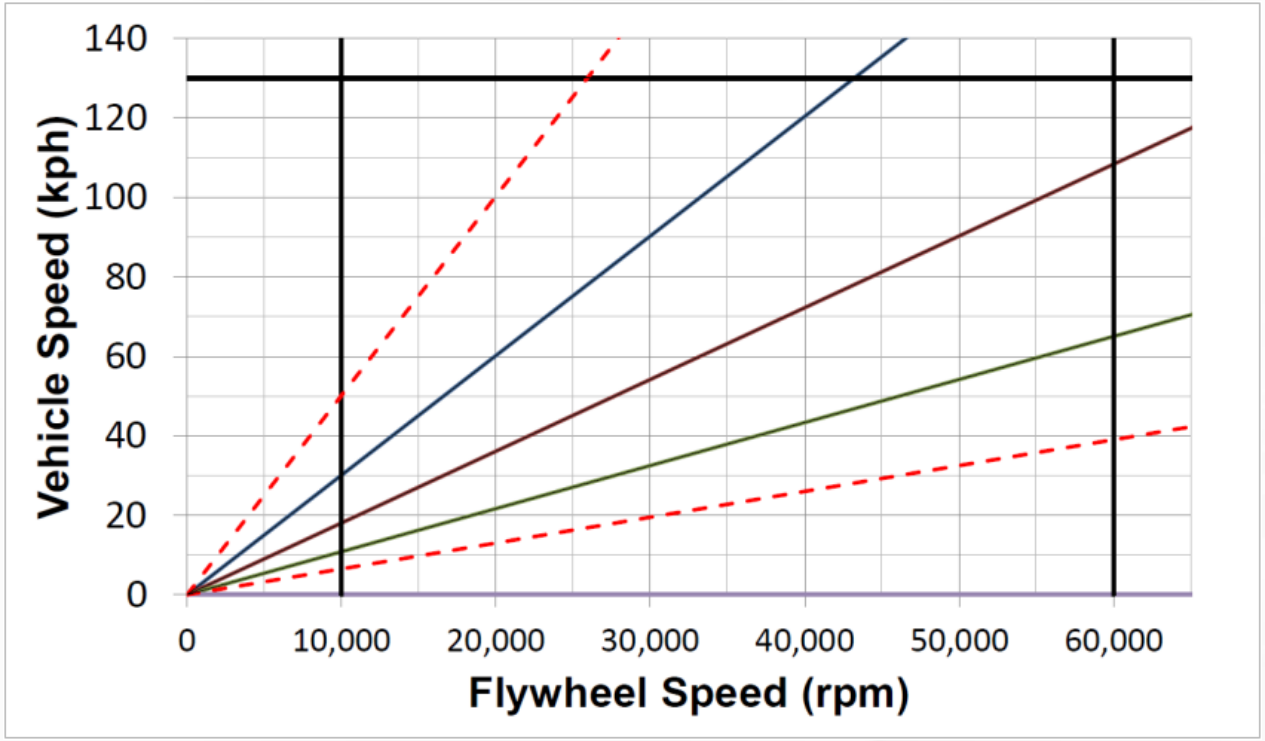
Overview

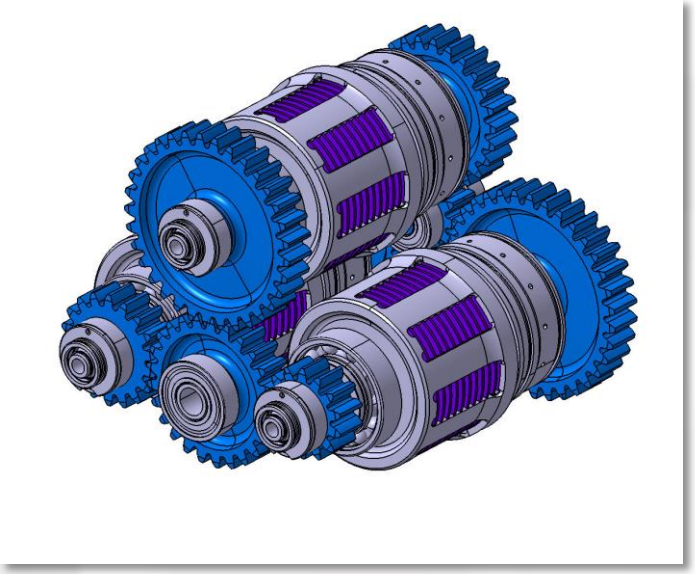
Principles of Flybrid Mechanical Hybrid Systems

- Flybrid Mechanical KERS store energy in a high speed flywheel.
- Steel hub with carbon Rim
- Different Flywheel sizes depending on storage capacity and life
- Speed up to 60,000rpm
- Energy storage proportional to speed squared
- Energy storage can be >1MJ

Overview

Clutched Friction Transmission





- A number of ratios are available – 3 in the graph
- Slipping the clutch allows energy to be transferred to/from the flywheel
- Multiple ratios are available to give a range of vehicle to flywheel ratios – can use the vehicle transmission too.
- A clutch may start with 30% slip and be used until 0% slip is achieved average slip is 15%, therefore 85% efficient

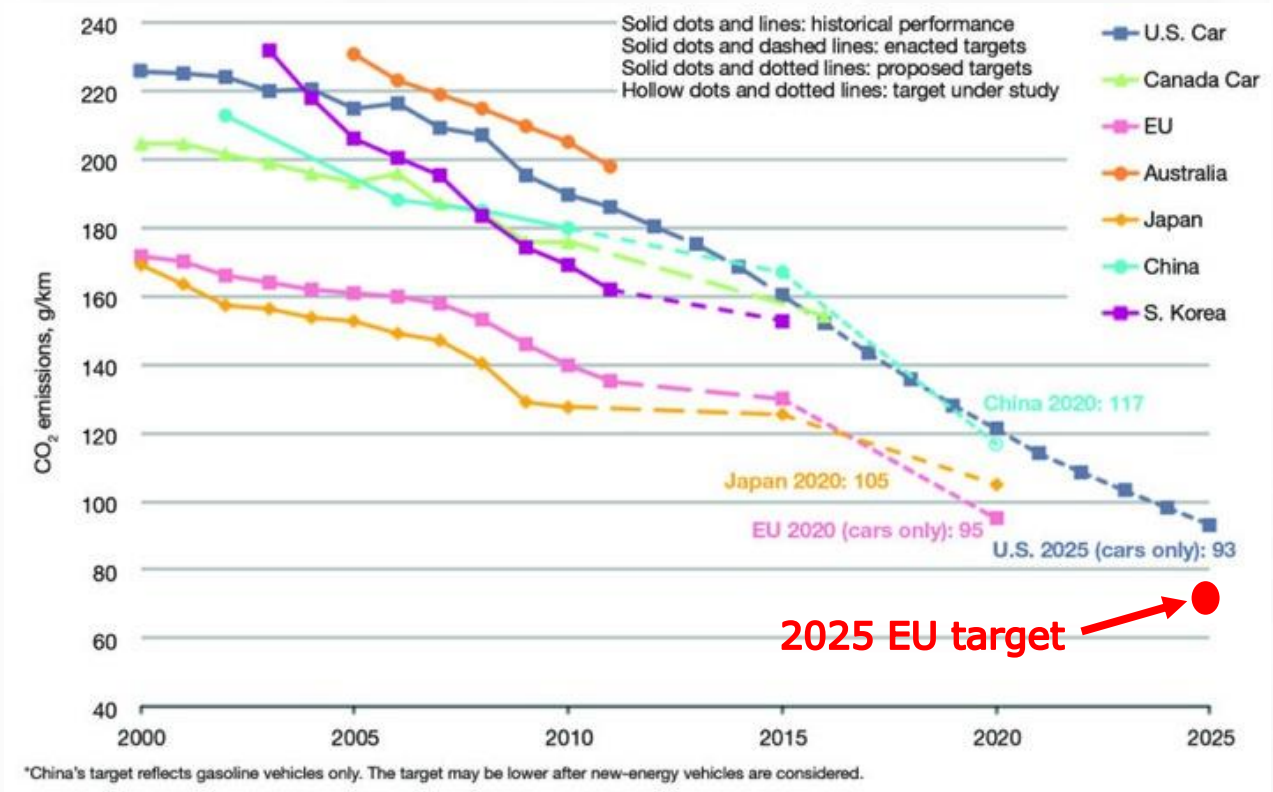
Performance and Durability

Performance

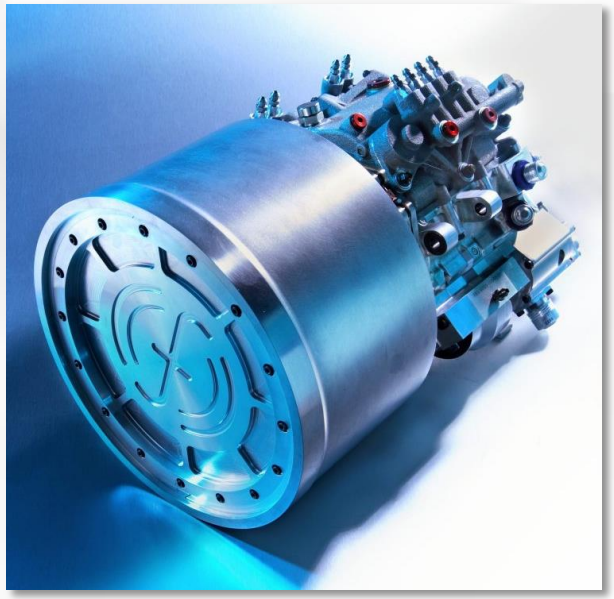
- Previous public projects in LMP1 had >100kW in a 40kg package with potential for >250kW power capacity through validation and testing.
- Since shown through rig testing that storage power in excess of 1000bph (~750kW) can be reliably achieved
- Clutch wear was measured during a durability test at this power level and was shown to be negligible
- Rig testing has also shown that with Torotrak's larger bus flywheel, storage energy can be increased to >1MJ for passenger car life
- Power density of 10kW/kg is achievable

Exploitation in Passenger Cars

Emissions targets

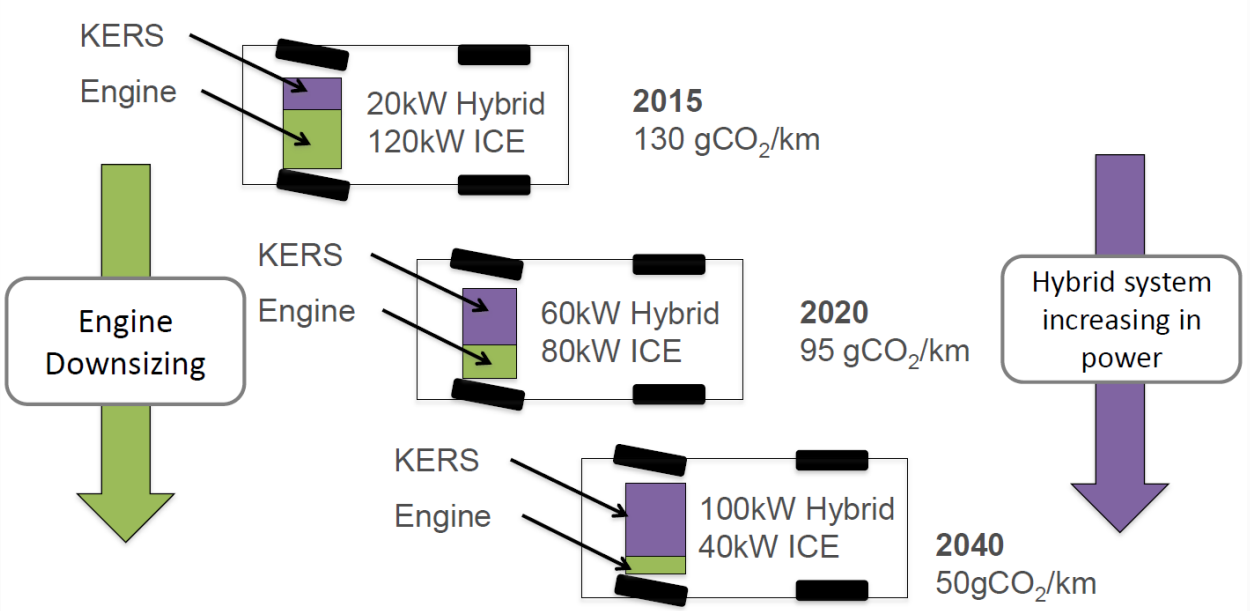


- 2025 EU emissions target is 70gCO_2/km
- Down sized engine is required to achieve this
- Large KERS will be required to maintain performance



Exploitation in Passenger Cars

Trends



- It has previously been shown that 1000kg passenger car with a 35kW prime mover, can achieve 71.9g CO_2/km for the NEDC (New European Drive Cycle) however vehicle performance for normal driving would be poor
- Adding a 60kW Flybrid KERS would further reduced to emissions to 66.8gCO_2/km.
- In this case, the hybrid system only improves CO_2 emissions by 7.8%, but gives a significant performance boost.

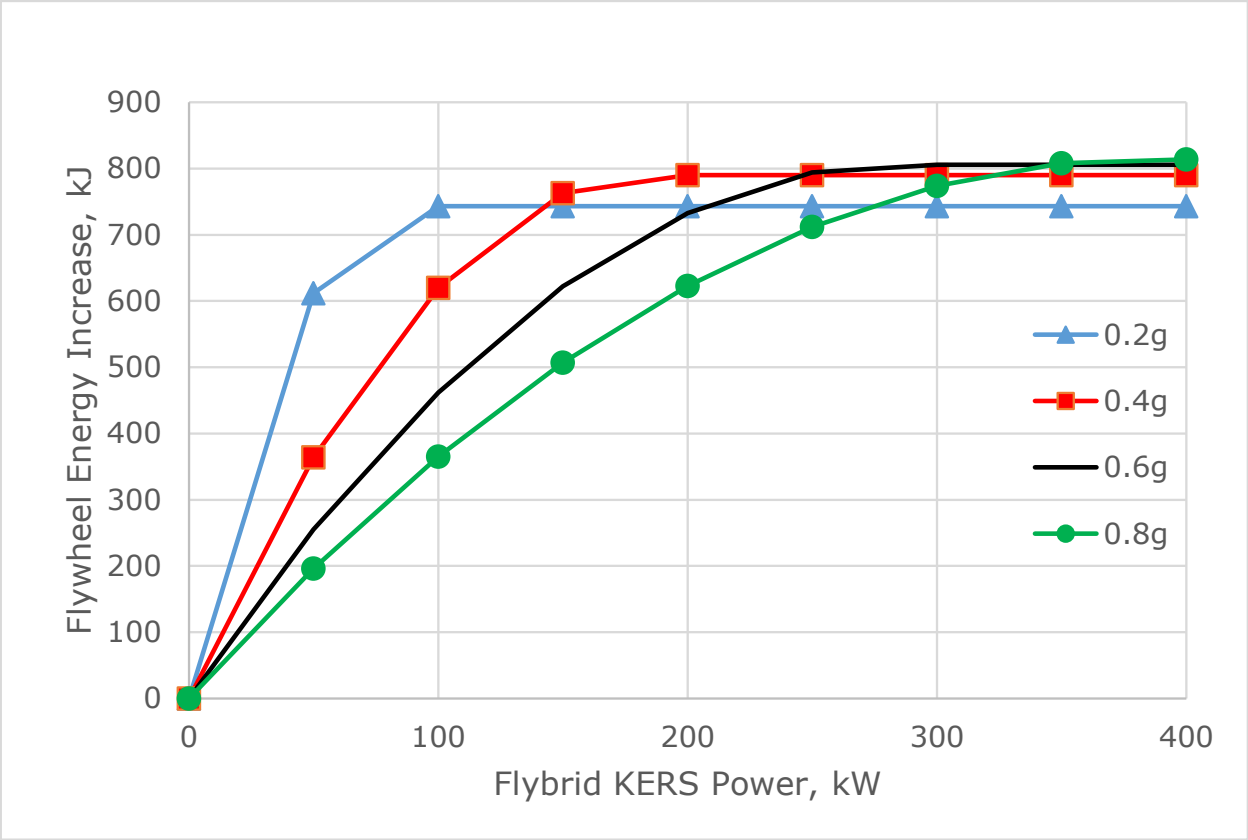
Exploitation in Passenger Cars

What can be achieved?

- A model of a car was constructed with
- Mass 1775kg
- CdA 0.75
- 30kW prime mover
- Assumed KERS energy transfer one way efficiency of 85%.
- The car was simulated to stop from 120kph and the energy that could be stored in the flywheel was determined.
- With a flywheel KERS it is also possible to pre-charge the KERS in a “sport” mode, this could keep the flywheel, at for example half speed all of the time, and result in an additional 25% more energy being available after a stop from 120kph.

Exploitation in Passenger Cars

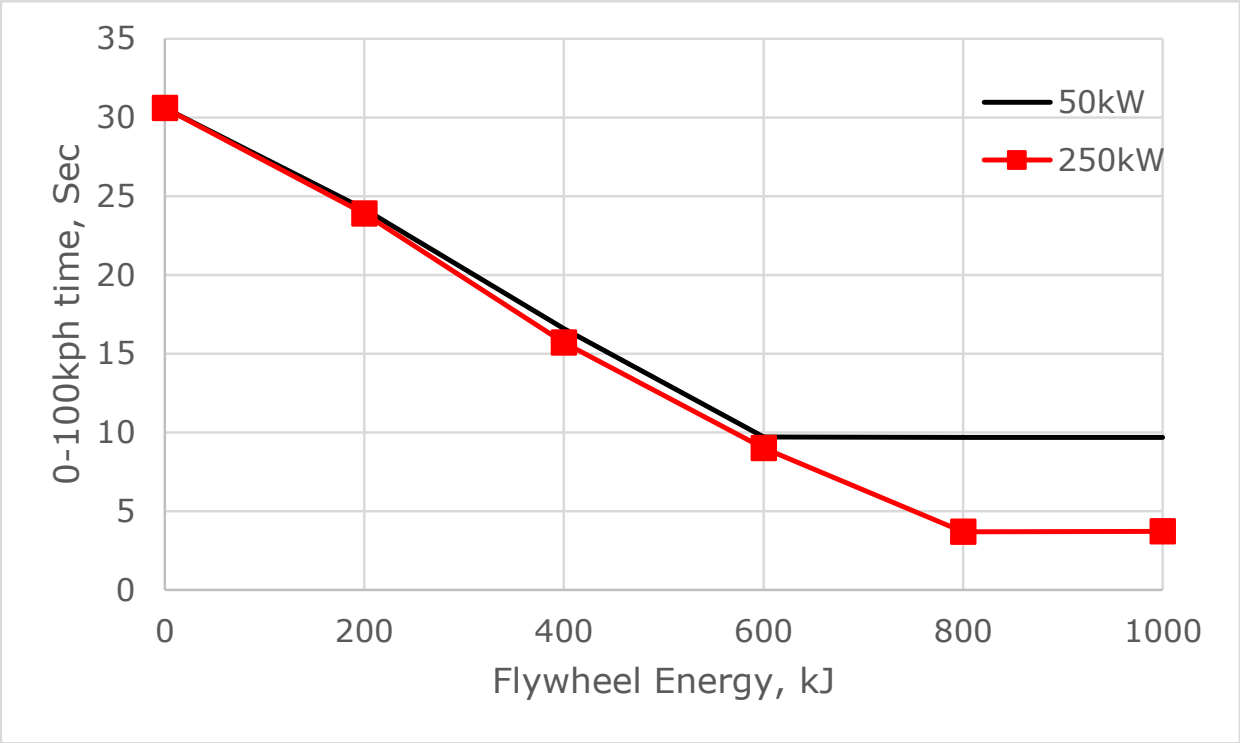
Energy Storage Capability



- Energy that can be stored was determined for different deceleration rates and KERS powers from 120kph
- Based on the data, it appears that up to 800kJ could be stored in the flywheel during braking
- At higher deceleration rates a higher power KERS is required to store most of the available energy
- In all cases the majority of available energy is stored when the Flybrid KERS power is more than 200kW.
- This assumes that the braking power can be achieved at the axle connected to the KERS.

Exploitation in Passenger Cars

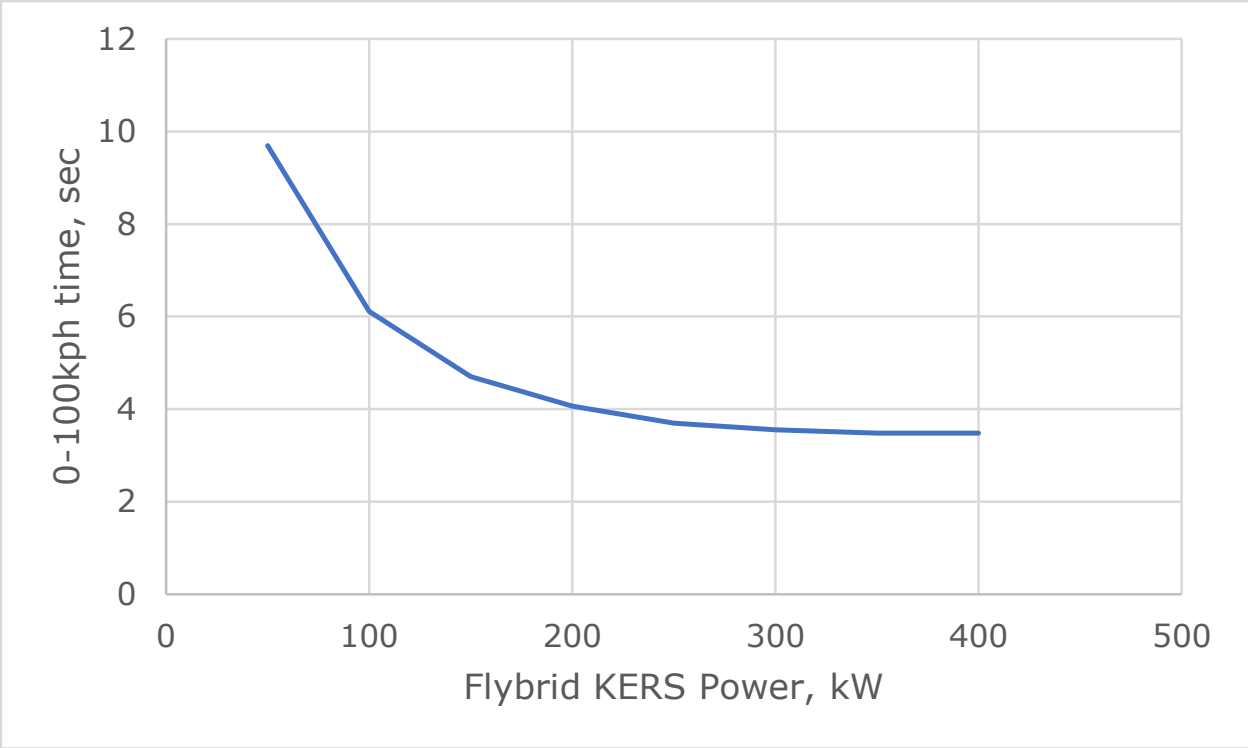
0-100 kph Acceleration With Different Power and Energy



- Acceleration Performance simulated.
- Assumed that 30kW was always available from the prime mover and power from the prime mover would be preferentially used.
- Vehicle performance for 0-100kph was simulated assuming that between 200 and 1000kJ of energy was available in the flywheel.
- With less than 600kJ of stored energy, the power of the Flybrid KERS makes little difference to the 0-100kph time as all of the flywheel energy is consumed before 100kph is reached.

Exploitation in Passenger Cars

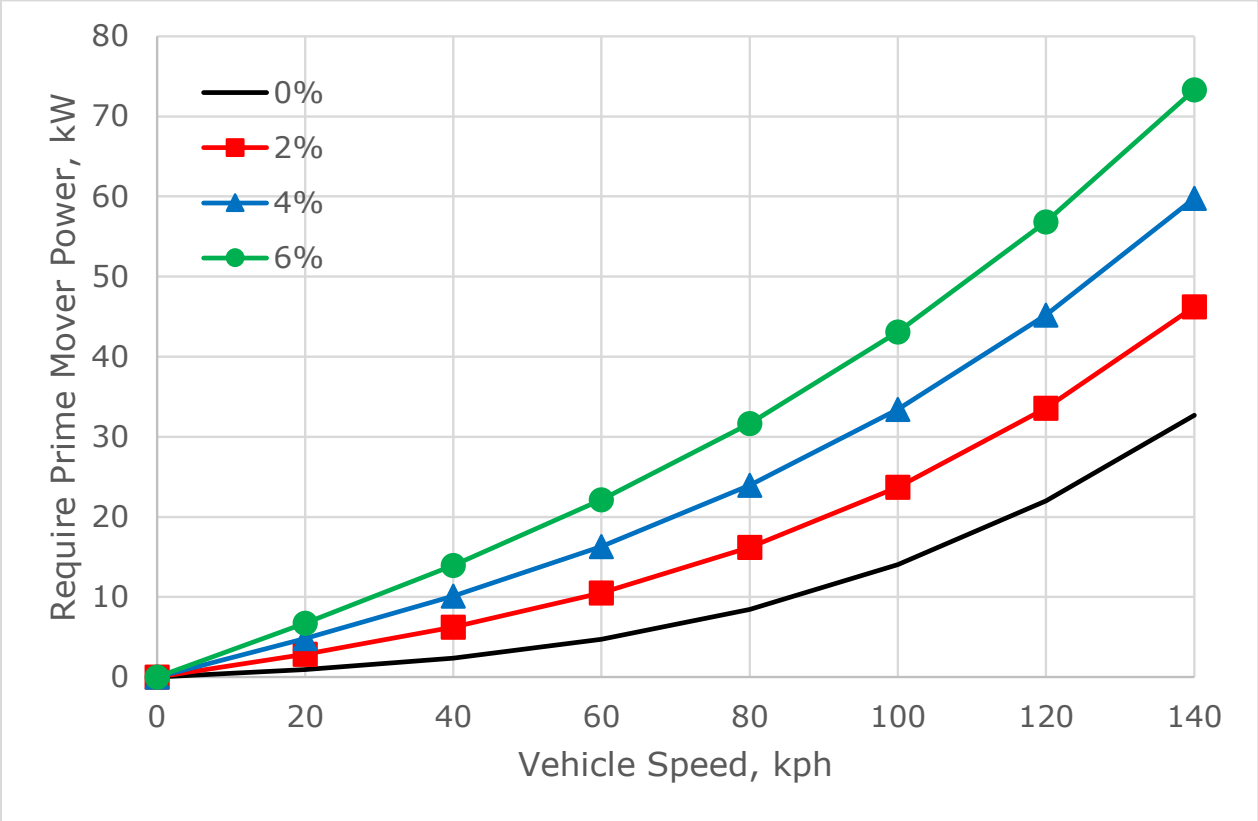
0-100 kph Acceleration With Different Power and 800kJ



- If 800kJ is stored, then the energy from the flywheel provides the majority of the energy required to accelerate the vehicle and therefore the vehicle performance to 100kph is very dependent on KERS power.
- With 800kJ of energy available, the vehicle performance can be in line with high performance sports cars, particularly if the KERS power is in excess of 200kW with 0-100kph times in the region of 4 seconds.
- A car with a downsized engine and 200kW Flybrid KERS would have very acceptable performance

Exploitation in Passenger Cars

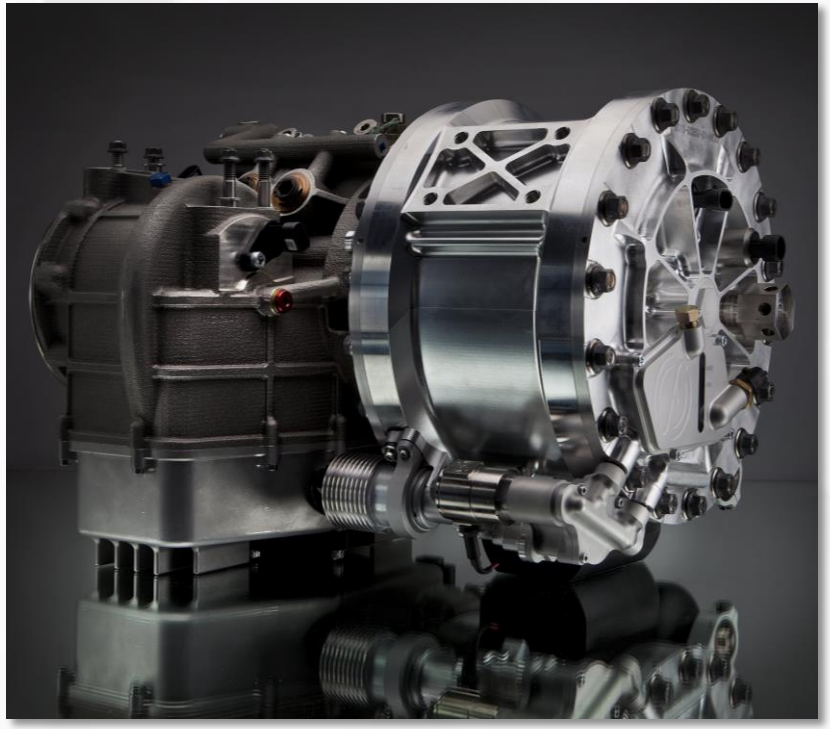
Gradeability and Power Requirement



- One issue for going too extreme on engine downsizing would be the ability for the car to go up long hills.
- For this vehicle, a 60kW prime mover would be required to go up a 6% gradient at 120kph
- Alternatively the vehicle's mass could be reduced and aerodynamic performance could be improved
- This should be considered carefully when going for an extreme downsized engine in a performance vehicle

Conclusions

- Engine downsizing + large KERS is likely to be the way to achieve 2025 emissions targets
- Torotrak's Flybrid Mechanical KERS has high power density and it has been shown through testing that 1000bhp (~750kW) storage power and >1MJ storage capacity is possible
- A 200kW KERS can store most of the braking energy at high deceleration rates
- With a 30kW prime mover, the 200kW KERS can provide high vehicle acceleration rates with 0-100kph around 4 seconds
- Prime mover size needs to be considered to ensure adequate gradeability



Thank you

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