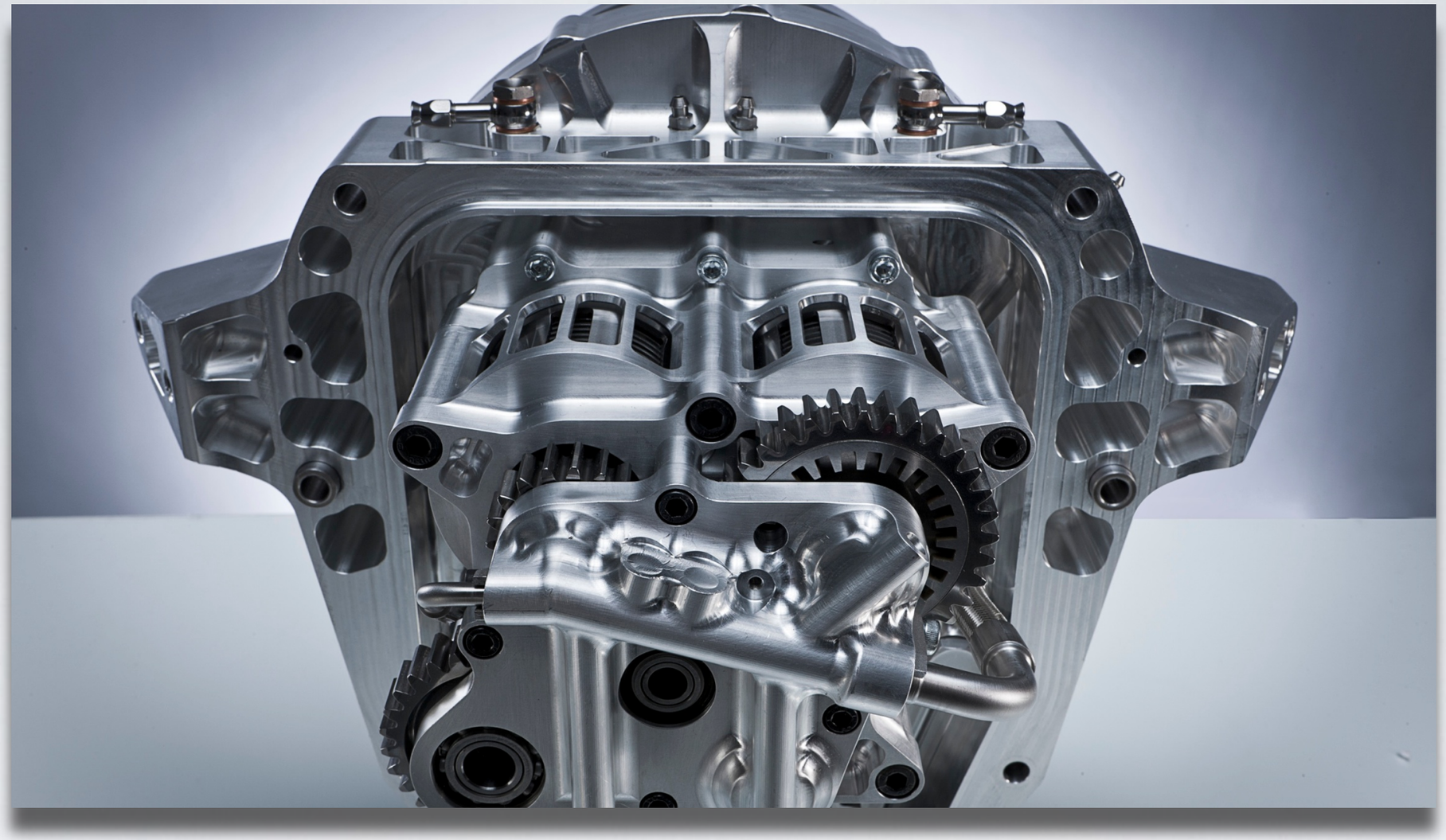


Why the fastest hybrid cars use flywheels

World's fastest hybrids

- On the 11th June 2011 the first ever hybrid car started the famous 24 hour race at Le Mans

- It was a privately run car with a high speed flywheel based hybrid system made by Flybrid

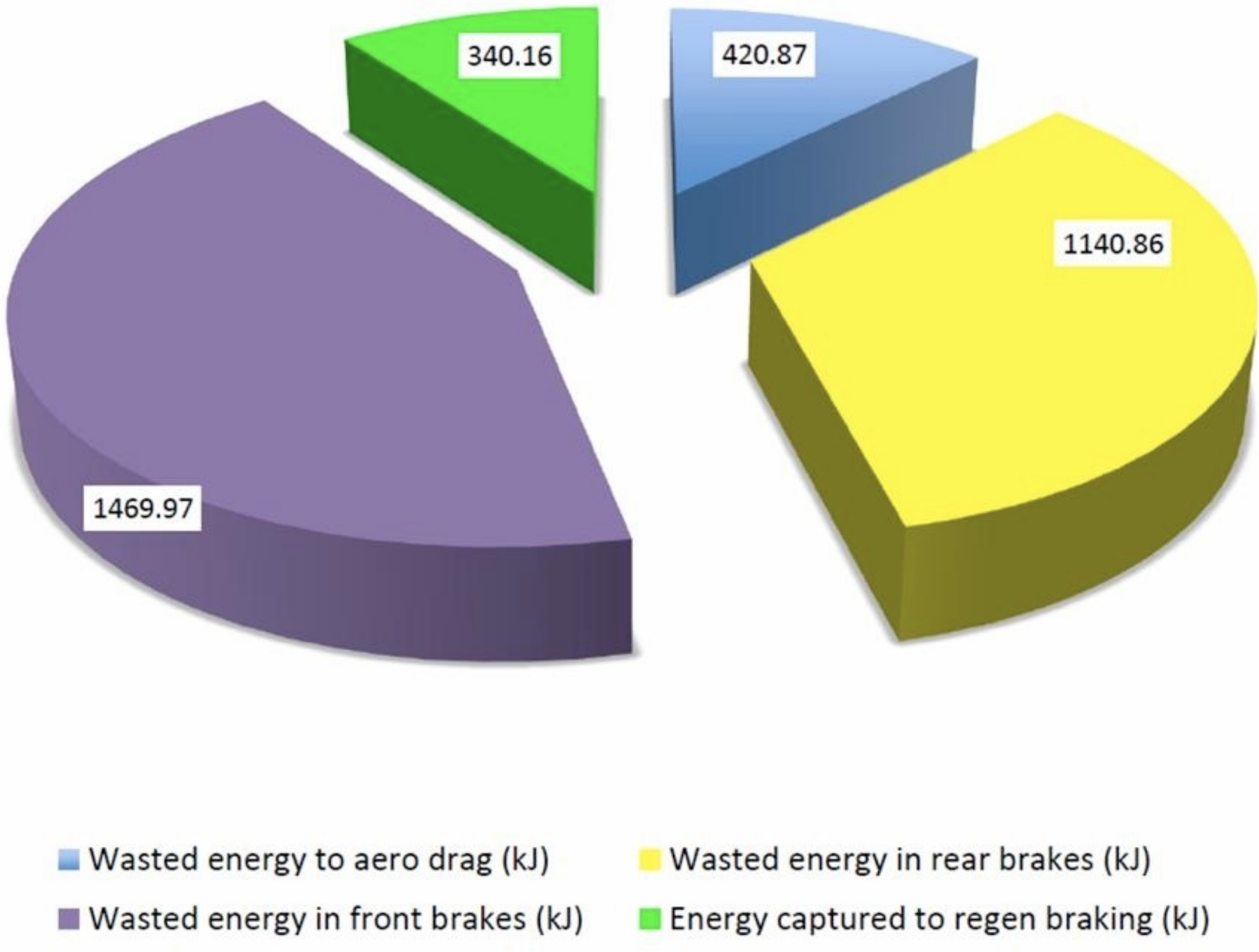
- In 2012 Audi head to Le Mans also using a flywheel hybrid system

Why flywheels?

racing Hybrid systems

- High power
- High efficiency
- Low weight
- Suitable energy storage capacity
- Low parasitics (cooling requirement, electrical requirement, aero drag, C of G height)
- Easy to use (pit equipment, logistics, driver controls)

Energy balance for vehicle delta KE during a braking event



Analysis

- Calculations show that it is difficult to capture very much of the wasted energy in a racing application
- The application requires high levels of power and is recovery side limited
- A relatively small amount of storage is needed
- The efficiency of the system will determine how much of this available energy can be captured and returned to the car
- System weight is critical as adding weight never makes a car go faster!

Flybrid CFT KERS

System specification

- Power - 100 kW
- Storage - 540 kJ
- Efficiency - 64% round trip
- Heat rejection - 5kW
- Homologated weight - 34.5 kg
- Installed weight - 37.9 kg

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The flywheel

- Made of steel and carbon fibre the flywheel can spin at up to 60,000 rpm
- It spins in a vacuum to reduce coast down losses and heat build up
- The housing has a containment structure but in fact the flywheel cannot burst
- Flybrid hold 22 patents and have 18 pending for the technology

Clutched flywheel transmission

- The Flybrid CFT KERS uses a series of small wet multi plate clutches to transfer energy between the flywheel and the car

- This transmission is capable of very high power levels yet can also be scaled down to small sizes for road car application

- The system is simple and robust with good round trip efficiency

Installation

- The KERS system is connected to the gearbox input shaft
- 3 CFT speeds are multiplied by 6 gearbox speeds to give 18 overall ratios
- CFT transmission sits in the top of the gearbox casing
- Gearing options provide for a range of engine speeds

Control system

- The CFT KERS uses a Flybrid developed control system
- Flybrid supplied the KERS control unit, the wiring loom, all the sensors and wrote the software code in-house
- Control is achieved with two hall effect speed sensors for high reliability
- Flybrid engineers work with the team and drivers to optimise the system

Road car applications

- This technology is coming to road cars soon with high volume vehicles going on sale in 2015

- The same characteristics that make the system perform well in a racing car help fuel consumption in a road car

- Adding weight never makes sense and adding cost even less so!

Road car applications

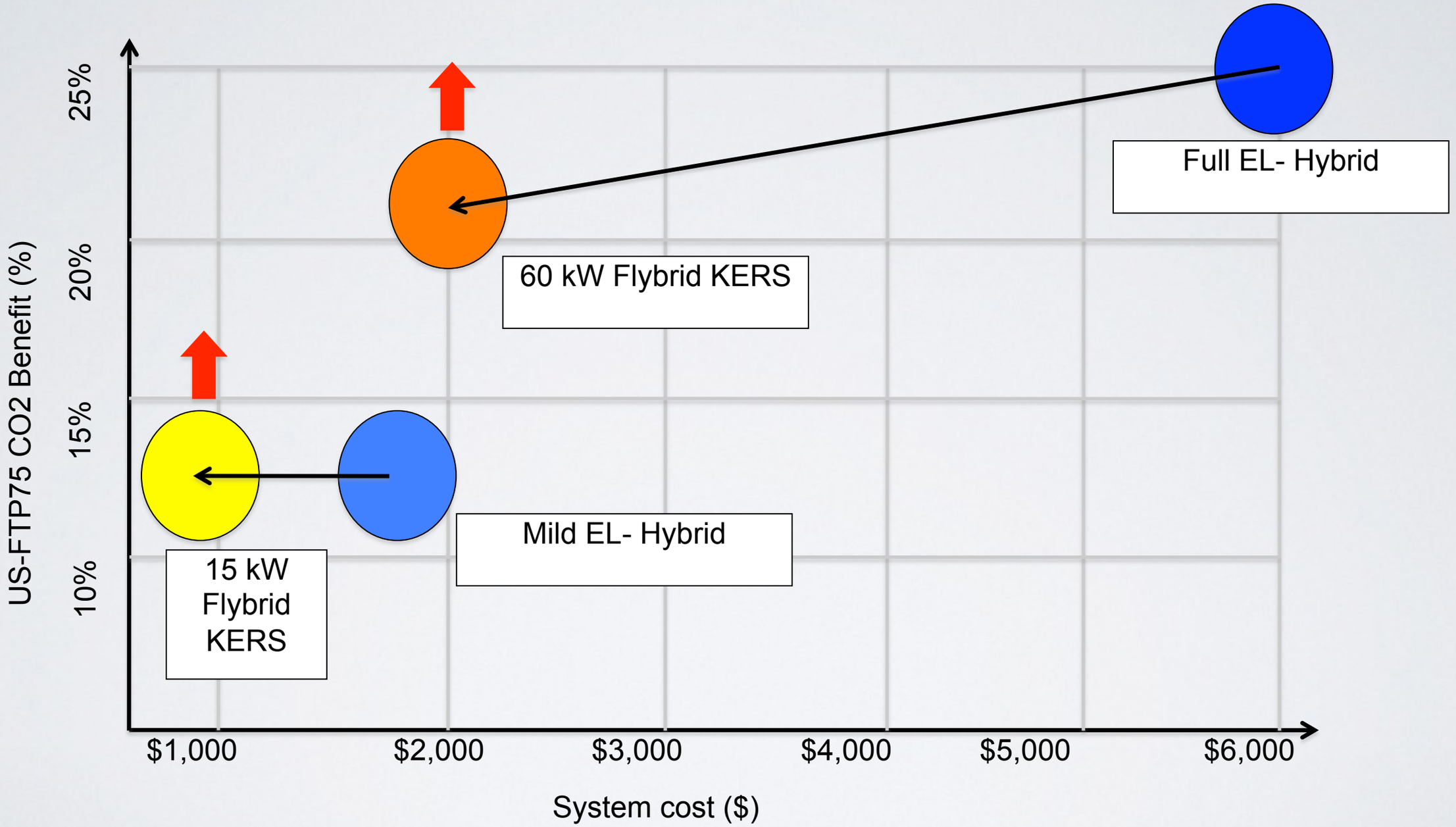
- The performance enhancing features of a race car developed hybrid system are of obvious benefit to sports cars

- But even family cars can use the performance benefit to achieve acceptable performance with a downsized engine

- There are many benefits of mechanical systems such as good performance over a wide temperature range, long life even on harsh duty cycles, low heat rejection and low system weight

- But the key advantage is cost / benefit ratio

Cost / Benefit



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