Transmission trends and the way forward
Transmission Tech 2017

11th April 2017

Ricardo India
Content

- Transmission trends in India
- Global transmission trends
- Electrification: The way forward
MTs will gradually decrease to c.80% market share through 2025; AMT will strengthen and DCT is likely to increase penetration

PV sales by transmission type (millions)

- MT will remain mainstream but continue to lose market share until 2025
- Increased AMT penetration due to similar FE & cost to MT
  - Maruti Suzuki, Mahindra, Renault & Tata have launched AMT
  - ‘e-AMTs’ to fuel growth for AMTs in future
- DCT will grow, given similarity in architecture with MT and a natural next step for efficiency
- AT will remain quite low penetration due to cost and technology barrier
- CVT already introduced by Nissan & Maruti Suzuki, however, its growth will be slow, will account for less than 2% share in 2025

Source: IHS, Ricardo analysis
Low cost and ease of driving are the current consumer priorities, while driving comfort and refinement are growing in importance.

### Overall customer expectations from transmissions

<table>
<thead>
<tr>
<th>Attribute Focus</th>
<th>Focus</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost</strong></td>
<td></td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Technical features, marketable, but only low pricing accepted</td>
<td></td>
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<tr>
<td><strong>Ease of Driving</strong></td>
<td></td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Highly important due to traffic congestions and poor road condition, importance increases as income increases</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Driving Comfort / Refinement</strong></td>
<td></td>
<td>L</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Expectation increasing as quality of localised products improves</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Technology Image</strong></td>
<td></td>
<td>M</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Technology valued by customers</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Efficiency / Env. Impact</strong></td>
<td></td>
<td>L</td>
<td>M</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• BS-6 and CO₂ regulations will drive higher efficiencies</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Performance Feel</strong></td>
<td></td>
<td>L</td>
<td>M</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Launch feel likely to become very important as customers get exposed to refined transmissions</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Market Taste / Expectation
- Predominately “3 pedal” market in future due to legacy and service network
- Currently accustomed to MT and view AMT for a low-cost route to “2 pedal”
- Modest uptake of AT/CVT/DCT in higher segment vehicles

Source: Ricardo analysis
While A- and B-segment will witness increasing penetration of AMTs, DCTs will grow share in C-segment due to efficiency

Transmission type penetration by vehicle segment

- A-segment vehicles are likely to witness an increasing penetration of AMT
  - Customers of A-segment cars are typically first time buyers or very price conscious or both
- B-segment with most volume will also see some shifts towards automation
  - AMT likely to be chosen for cheaper cars
  - DCT used in relatively more expensive models offering shift refinement
- C-segment’s automation level likely to remain same
  - DCTs are likely to grow mainly due to efficiency and it’s similarity with MT architecture

Source: IHS, Ricardo analysis
Automated transmissions take a larger share of the low volume D-/E-segments, as shift quality and refinement are key requirements.

**Transmission type penetration by vehicle segment**

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>D-segment</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mini/Compact</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compact Full</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frame</td>
<td>1%</td>
<td>6%</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>98%</td>
<td>93%</td>
<td>93%</td>
</tr>
<tr>
<td></td>
<td>360k</td>
<td>420k</td>
<td>690k</td>
</tr>
<tr>
<td><strong>E-segment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mini/Compact</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compact Full</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frame</td>
<td>11%</td>
<td>13%</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>59%</td>
<td>55%</td>
<td>51%</td>
</tr>
<tr>
<td></td>
<td>11k</td>
<td>15k</td>
<td>36k</td>
</tr>
<tr>
<td><strong>DCT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>CVT</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td><strong>AT</strong></td>
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<tr>
<td><strong>AMT</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Manual</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **D-segment** comprised c.1% of the total PV production in 2015 however its share is likely to double by 2020
  - c.70% of PVs in D-segment use automated transmissions, essentially ATs and DCTs and will continue this till 2025
- **E-segment** has considerably greater penetration of ATs owing to several Mercedes and BMW models in it
  - Slow shift likely from ATs towards CVTs and DCTs as FE becomes central
- **Ladder frame SUVs/MPVs** largely comprise Mahindra, Tata and Toyota vehicles
  - MTs are predominant but penetration of ATs is likely in premium SUVs

Source: IHS, Ricardo analysis
Content

- Transmission trends in India
- **Global transmission trends**
- Electrification: The way forward
MTs are gradually losing market share and would constitute c.35% of transmissions by 2025; automated transmissions are growing

Global light vehicle (LV) production by transmission type (millions)

- Global light vehicle production is expected to cross 105M by 2025
  - Most of growth is expected to come from Asia, especially China and India
- As most markets warm up to automated transmissions, MT demand is expected to remain flat, driving them to lose share
- DCTs and CVTs are expected to grow faster while AT demand is likely to reduce
  - Stricter CO$_2$ norms bring focus on efficiency
  - Advances in DCT & CVT technology expected to bring down their price
- AMT would continue being an economical path to automation, especially in lower vehicle segments

Global transmission trends

![Graph showing global light vehicle production by transmission type (millions)](image-url)
Global transmission trends

Both North America and Europe are very different transmission markets historically; both are changing towards a different mix

Regional penetration of automated transmissions – 2016

- North American market has been historically an AT market
  - Fuel efficiency was neither pushed by legislation nor pulled by customers
- CVTs have gained some traction while DCTs continue to be avoided against ATs

- Europe has largely been a MT market with some AT penetration
- However MT market share is steadily dropping due to absence of customer demand
- Also, a majority of hybrid transmissions will be based on ATs or DCTs

Source: IHS, Ricardo analysis

LV – 0-3.5 T GVW
In China DCTs are likely to grow while market share of MTs would decrease; Japan/Korea will see more of electrified transmissions

Regional penetration of automated transmissions – 2016

- Historically a MT market, the share of MTs is reducing fast
- A significant investment has been made into DCTs which would keep driving its use
- A strong push towards NEVs is also going to drive electrified transmission configurations with ATs and DCTs

Source: IHS, Ricardo analysis
Global transmission trends

Transmission concepts will evolve for weight, efficiency and cost improvements, with increasing e-machine integration opportunities.

<table>
<thead>
<tr>
<th>Source: Ricardo Analysis</th>
</tr>
</thead>
</table>

### Global Light Vehicle Transmissions Technology Roadmap

<table>
<thead>
<tr>
<th>Year</th>
<th>Manual (MT)</th>
<th>Automated Manual (AMT)</th>
<th>Dual Clutch (DCT)</th>
<th>Automatic (AT)</th>
<th>CVT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>6 speed</td>
<td>6 speed</td>
<td>Wet Clutch (Open Hydraulic)</td>
<td>6 speed</td>
<td>Push Belt, Chain, Dry Belt</td>
</tr>
<tr>
<td>2010</td>
<td>Next Gen 6 speed</td>
<td>Torque Interrupt (Hydraulic or Electro-Mechanical) Actuation</td>
<td>Wet Clutch (closed hydraulic)</td>
<td>7 and 8 speed</td>
<td>2 and 3 range CVT</td>
</tr>
<tr>
<td>2015</td>
<td>7 speed</td>
<td>P2/P3 Torque fill AMT</td>
<td>6 – 8 speed</td>
<td>9 and 10 speed</td>
<td>ePowersplit IVT</td>
</tr>
<tr>
<td>2020</td>
<td>6 speed with E-clutch &amp; mild hybridisation</td>
<td>P4 low cost Torque fill AMT</td>
<td>Next gen modular low weight efficient DCT</td>
<td>Hybridisation (P2 and later P2.5)</td>
<td></td>
</tr>
<tr>
<td>2025</td>
<td>Next Gen 6 speed</td>
<td>P3 / P4 Powershift</td>
<td>Wet Launch Clutch / High Efficiency Actuation / Latching</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**54.5 mpg CAFÉ?**

**68 g/km CO₂ target?**

**Global Light Vehicle Transmissions Technology Roadmap**

- **Manual (MT):**
  - 6 speed
  - Next Gen 6 speed

- **Automated Manual (AMT):**
  - Torque Interrupt (Hydraulic or Electro-Mechanical) Actuation
  - P2/P3 Torque fill AMT
  - P4 low cost Torque fill AMT

- **Dual Clutch (DCT):**
  - Wet Clutch (Open Hydraulic)
  - Wet Clutch (closed hydraulic)
  - Next gen modular low weight efficient DCT
  - P3 / P4 Powershift

- **Automatic (AT):**
  - 6 speed
  - 7 and 8 speed
  - 9 and 10 speed
  - Hybridisation (P2 and later P2.5)
  - Wet Launch Clutch / High Efficiency Actuation / Latching

- **CVT:**
  - Push Belt, Chain, Dry Belt
  - 2 and 3 range CVT
  - ePowersplit IVT
The trend for automated transmissions is expected to see E-H actuation grow in DCT and E-M actuation grow with AMT

Clutch actuation outlook

<table>
<thead>
<tr>
<th>MTs</th>
<th>DCTs</th>
<th>AMTs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Trend to 2025</td>
<td>Type</td>
</tr>
<tr>
<td>Mech. cable</td>
<td></td>
<td>Mech. cable</td>
</tr>
<tr>
<td>Hydraulic</td>
<td></td>
<td>Hydraulic</td>
</tr>
<tr>
<td>Electro-hydraulic</td>
<td></td>
<td>Electro-hydraulic</td>
</tr>
</tbody>
</table>

- Most MT clutches use hydraulic actuation today due to simplicity of use, robustness and flexibility for various powertrains
- As e-clutch systems gain more appeal for comfort and safety, use of EH clutch actuation is likely to increase
- Towards 2025, still a major fraction of MT clutches will remain hydraulically actuated
- Actuation in DCT clutches is currently divided between EH and EM systems
  - EH is going to grow as it can be used on both dry & wet
  - EM typically applied only on dry clutches, is likely to remain strong where efficiency and packaging are key criteria
- AMTs clutches mainly use EH actuation currently
  - As shift quality becomes important for the adoption of AMTs, possibility of moving towards EM actuation
  - Also, as manufacturers look for synergy between AMTs and DCTs, a further shift towards EM clutch actuation is likely

Source: Ricardo analysis
EH – Electro-hydraulic
EM – Electro-mechanical
The choice between wet and dry clutch technology is difficult; depends mainly on vehicle class and overall system setup.

### Dual Clutch Transmission (DCT) – Dry vs. wet coupling

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Wet clutch DCT</th>
<th>Dry clutch DCT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A wet clutch</strong> is immersed in a cooling lubricating fluid which also keeps the surfaces clean and gives smoother performance and longer life.</td>
<td></td>
<td>Dry clutches don’t use any liquids for cooling or lubrication.</td>
</tr>
<tr>
<td>Wet clutches, whilst being able to handle higher torque loads (&gt;250Nm) are both expensive and complicated</td>
<td></td>
<td>Dry clutches are generally more common as launch devices and their characteristics remain almost unchanged during their service life, even after a degree of overloading.</td>
</tr>
<tr>
<td>They also require more energy to overcome hydraulic losses, and are therefore less intrinsically economic.</td>
<td></td>
<td>Dry clutches are more economic to manufacture and may deliver better fuel economy.</td>
</tr>
<tr>
<td>Wet clutches are mainly used for D-segment vehicles and above.</td>
<td></td>
<td>Friction characteristic of dry clutch can create heat that leads to very fast clutch plate wear and significantly shortening clutch life.</td>
</tr>
<tr>
<td>Mainly actuated electro-hydraulically for both clutch and gear shift.</td>
<td></td>
<td>Actuated electro-hydraulically or electro-mechanically (depending on overall system design).</td>
</tr>
</tbody>
</table>

Source: Ricardo
Both dry and wet clutch systems are likely to co-exist in 2025; wet systems to be the majority as costs drop and performance improves

Wet vs. Dry clutch DCT market outlook (global)

- Current market is roughly split between dry and wet clutch DCTs evenly, dry having a slight edge
- Ford’s PowerShift DCT, developed with Getrag and LuK, was initially launched with a wet clutch, but in recent compact cars, dry clutch has been launched
- Volkswagen uses two variants, 6 speed wet DCT and 7 speed dry DCT across various segments
- With the current emphasis on costs, efficiency and NVH, both types are able to find similar volume of applications in PVs

- Dry clutch is particularly suited for lower torque applications, markets like EU and China are likely to choose it mainly for volume segments (A/B/C)
- Higher torque capacity, continual improvements in wet clutch efficiency and superior NVH characteristics would drive the growth of wet and grow its share in medium/higher vehicle segments
- As costs drop and wet clutch becomes more competitive, lower segment PVs would also adopt it
- Consequently, both will continue to co-exist in 2025, though wet clutch would have major share

Source: Ricardo analysis
Content

- Transmission trends in India
- Global transmission trends
- **Electrification: The way forward**
Transmission technology is being driven mainly by CO$_2$ legislation however is impacted by electrification and customer requirements

**Transmission technology – Drivers**

**Fuel economy**
- Legislation is the most important driver for transmission technology developments
- CO$_2$ targets around the world are converging to c.4L/100 km
- While customers expectations are driving the growth of relatively inefficient automated transmissions
- There is large scope for improvement of transmission efficiency, especially CVT & AT

**Packaging & safety**
- In many countries, legal requirements influence the space the bonnet referring to pedestrian and occupant safety and related additional space for bonnet deformation
- Transmissions are also affected by light-weighting requirements and consistent demand for performance that needs to be aligned with the OEMs’ interest in additional space for interior systems

**Driving comfort**
- Customer decision is primarily driven by obvious attributes, e.g. design, infotainment, brand image, etc.
- Driving comfort and handling would be the obvious and important attributes initially
- As incomes increase and urbanisation continues, customer expectations from transmissions will increase; launch feel, shift quality etc. would start to matter more

**Electrification**
- There is a significant trend of electrification across the world
- Western OEMs focus on highly advanced ICEs, further to be optimized with xEV technologies
- Chinese OEMs rather focus on xEV due to limited access to advanced ICE technology and strong government support for xEVs

*Source: Ricardo*
Fuel consumption targets in all major markets are converging to 4L/100km in 2020+, forming a strong basis for vehicle electrification.

Global Regulated & Planned Targets for Fuel Consumption & CO_{2}

- Fuel consumption legislation already in place for major vehicle markets globally.
- EU has led global FC regulation for several years with fleet average target set aggressively at 95g/km by 2020.
- China has proposed ambitious phase 4 target for 2020 with 117g/km (~5.0L/100km), which will rapidly close the gap with EU.
- India has announced a target of 4.8L/100 km (113 g/km CO_{2}) for 2022.
- Tightened fuel emissions legislation is main driver for push into xEVs.

[1] China’s target reflects gasoline vehicles only. The target may be higher after new energy vehicles are considered.
[2] The U.S. standards are fuel economy standards set by NHTSA, which is slightly different from GHG standards due to A/C credits.
[3] Gasoline in Brazil contains 22% of ethanol (E22), all data in the chart have been converted to gasoline (E00) equivalent.

Source: EMLEG, Ricardo
Transmission and driveline electrification are highly likely to become mainstream in the next 10-15 years

Transmission and driveline electrification

- **12V improved system**
  - S&S, coasting/Sailing stop, light regeneration

- **48V EM on Engine**
  - Same functions as 12V with more power + some 48V ancillaries

**Impact on transmission**

- **2020 EU legislation**
  - Improved regeneration, EV

- **2025 EU legislation**
  - 48V EM in transmission
  - Improved regeneration, EV
  - -10-15%

- **2030 EU legislation?**
  - HV EM in transmission
  - Same as 48V in transmission with more power, some HV ancillaries
  - -10-20%

- **PHEV**
  - To use low carbon energy, good EV capability in urban

- **BEV**
  - Zero local emission, use of low carbon energy

**Source:** Ricardo
Electrification: The way forward

Current development is tending to integrate the electrical machine into a modular P2 or P4 architecture

Different Hybrid Passenger Vehicle Architectures

<table>
<thead>
<tr>
<th>Parallel Hybrid Configurations</th>
<th>Label</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="P1 Diagram" /></td>
<td>P1</td>
<td>Electrical machine is integrated with the engine crankshaft</td>
</tr>
<tr>
<td><img src="image" alt="P1/2 Diagram" /></td>
<td>P1 / 2</td>
<td>Either a single motor and two clutches (shown) or two motors and one clutch, between the engine and transmission</td>
</tr>
<tr>
<td><img src="image" alt="P2 Diagram" /></td>
<td>P2</td>
<td>Electrical machine is integrated with the input shaft to the transmission</td>
</tr>
<tr>
<td><img src="image" alt="P3 Diagram" /></td>
<td>P3</td>
<td>Electrical machine is integrated with the output shaft from the transmission</td>
</tr>
<tr>
<td><img src="image" alt="P4 Diagram" /></td>
<td>P4</td>
<td>Electrical machine is mounted on the rear axle (may require a reduction gear)</td>
</tr>
</tbody>
</table>

Source: Ricardo analysis
Unlike the GTC I that had P0 architecture, GTC II co-developed by Schaeffler and Continental is a 48 V mild P2 hybrid with a BSG.

### Continental x Schaeffler GTC II (P2)

**Schematic**

**Key components**
- 1.0L 3 cylinder EcoBoost (Gasoline) engine
- Standard turbocharger
- 48 V Belt Starter Generator (BSG, P2 configuration)
- 48 V electrical vacuum pump, water pump
- 48 V electrically heated catalyst
- Decoupling clutches, bearing and tensioner

**Functionality**
- E-motor runs between engine and transmission, is coupled to the drivetrain by a belt and 2 clutches
- Supports both constant-speed electric sailing at low load and a pure electric launch
- GTC II claims to get 17% FE benefit over Ford Focus 1.0L EcoBoost (NEDC)

**Comments**
- Each of the two partners have developed their own 48 V mild hybrid prototypes
- Schaeffler has a 48 V electric rear axle + BSG (P0) while Continental 48 V EcoDrive is a BSG (P0)

Source: Ricardo, Schaeffler GTC II brochure

Schaeffler has developed a 48 V hybrid module that uses integrated automated clutches and e-motor within one package

**Schaeffler 48 V Hybrid Module (P2)**

**Schematic**

**Key components**
- Modular hybrid module
  - 48 V, 12 kW E-motor
  - Integrated automated clutches
    - Start-up clutch
    - Disconnect clutch

**Functionality**
- Can be mounted as a unit between the ICE and transmission without any changes to transmission
- Achieves electric creep, electric launch assist and brake energy recovery in all gears
- No additional engine starter and no damper required

**Comments**
- With the hybrid module, Schaeffler has modularised P2 mild hybrid functionality
- Schaeffler claims possibility of 12-16% CO$_2$ reduction using hybrid module

Source: Ricardo, Schaeffler GTC II brochure

GTC – Gasoline Technology Vehicle, DMF – Dual Mass Flywheel, HMI – Human Machine Interface, LIVC – Late Intake Valve Closing

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Transmission Tech 2017

April 2017
Hybrid transmissions can be developed using a conventional base transmission or by creating a Dedicated Hybrid Transmission (DHT)

Approaches to hybridise transmissions

**Approach 1: Reuse and adapt conventional powertrains - take an existing AT and add an electric motor in P2 or P4 position**

- **ZF 8P70H**
- Less initial investment
- BUT Bad impact on BOM cost, weight, efficiency,
- Natural first step for low expected market share

**Approach 2: Dedicated Hybrid Transmission - Development of bespoke / optimised transmission with integrated electrical motors (E.g. Prius, Volt, Outlander, Renault Eolab)**

- **GM Volt**
- High initial investment
- BUT Optimised solution
- Early adopters successful. High potential for 2025

Source: Ricardo analysis
Dedicated Hybrid Transmissions can offer several benefits over hybridised transmissions however they require new investments

### Hybridised Transmissions vs. Dedicated Hybrid Transmissions

<table>
<thead>
<tr>
<th>Compared to conventional trans.</th>
<th>Conventional Hybridised Transmission</th>
<th>Dedicated Hybrid Transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit cost</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>Weight</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>Package volume</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>Complexity</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>NVH quality</td>
<td>-</td>
<td>M</td>
</tr>
<tr>
<td>Required functions for vehicle</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Base transmission efficiency</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>Powertrain efficiency</td>
<td>M</td>
<td>H</td>
</tr>
<tr>
<td>Development cost</td>
<td>L</td>
<td>H</td>
</tr>
</tbody>
</table>

- Dedicated Hybrid Transmissions (DHTs) can be defined as 'a transmission requiring an e-machine(s) in the drivetrain to undertake its desired function
- DHTs can be a good choice for future powertrains which are highly electrified but based on ICEs
- DHT architecture is not distinct and could be based on DCT, AMT, EVT or AT
  - Arrangement can have any number of speeds, modes or torque sources
- DHTs offer improved efficiency and lower BOM cost though they need new investment
  - Higher volumes are needed to offset increased investment

Source: Ricardo analysis
Typical hybrid vehicles use P1/2 configuration which raises number of clutches; DHTs may eliminate bespoke clutches in the long term

<table>
<thead>
<tr>
<th>Impact of transmission electrification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golf GTE</td>
</tr>
<tr>
<td>Single plate dry clutch</td>
</tr>
</tbody>
</table>

- Several European OEMs are developing cars with this config
- Its success could open new market opportunities for clutches in xEVs
- The popular Toyota HSD system uses E/E to transmit torque
- This is a Dedicated Hybrid Transmission without any clutch
- Honda i-DCD is a hybridised conventional DCT (approach 1)
- Pure electric launch and low speed driving is possible with this

Source: Ricardo analysis, Honda website, Toyota website
Electric Vehicles may be poised for growth, however the optimum architecture for EV transmissions isn’t very clear yet.

Options for Electric Vehicle Transmissions (EVT)

- Typical EVT have simple characteristics like having no clutch for single speed and having low number of gears.
- The primary challenge revolves around NVH where in specific gear design process is necessary.
- In addition, lubricant / thermal viscosity is key to having an appropriate EVT.
- There are multiple architectures in use, some with single and some with multiple gears.

Source: Ricardo analysis, Gas2.org, Drivelineweek GKN
In a dynamic environment, the challenges faced by transmission designers are multi-dimensional; need to address each to succeed

Key implications for transmission designers

- **Offer wide product range**
  - The need for diverse product offerings is greater than ever
  - No single product or technology is the sole solution
  - Transmission designers need to be able to provide a range of products for conventional as well as electrified powertrains

- **Analyse market dynamics**
  - Market is highly dynamic in nature, influenced by volatility in economic growth, customer expectations, personal mobility patterns and regulation
  - Closely tracking changes to tune products can mean the difference between success and failure

- **Track technological advances**
  - Technological changes are driven mainly by regulation and regulations continue to evolve with time
  - Technology costs are critical for inclusion in products but are uncertain
  - Transmission designers need to closely assess cost-benefit ratio and optimize products to cope up with technological advancements

- **Assess new growth opportunities**
  - Markets can be characterised into leaders and followers; products in leader markets often are applicable in follower markets, after a time gap
  - Transmission designers need to closely monitor growth opportunities in follower markets and capitalise on similar customer requirements

Source: Ricardo Analysis