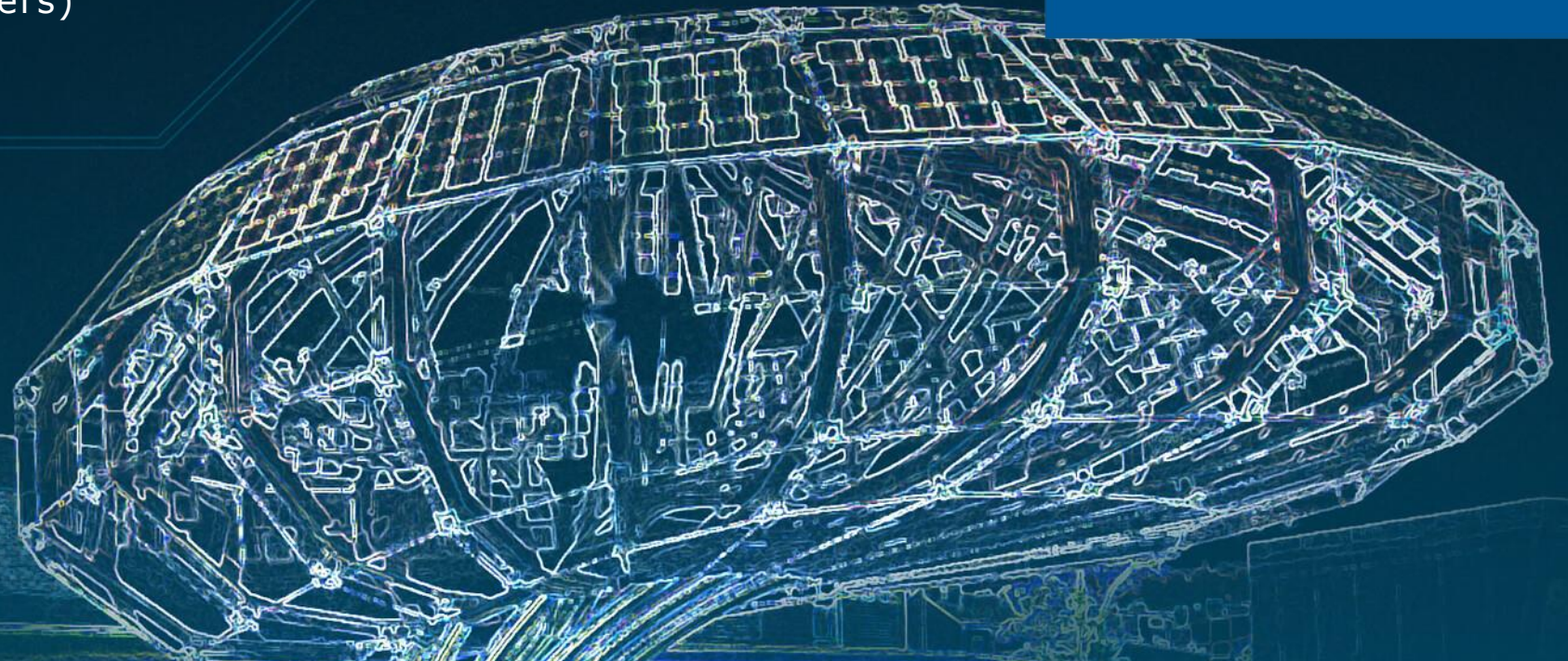
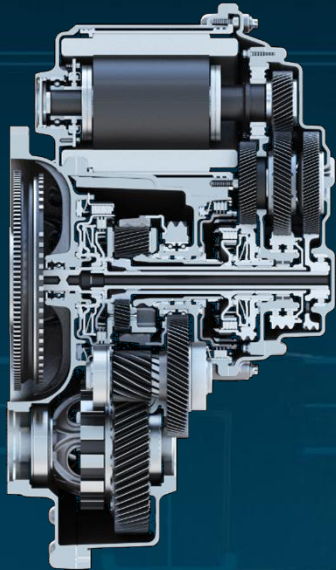


Ivan Andrašec

Bernd Jeitler

AVL List GmbH (Headquarters)



AVL's Future Hybrid X Mode

a modular transmission family concept

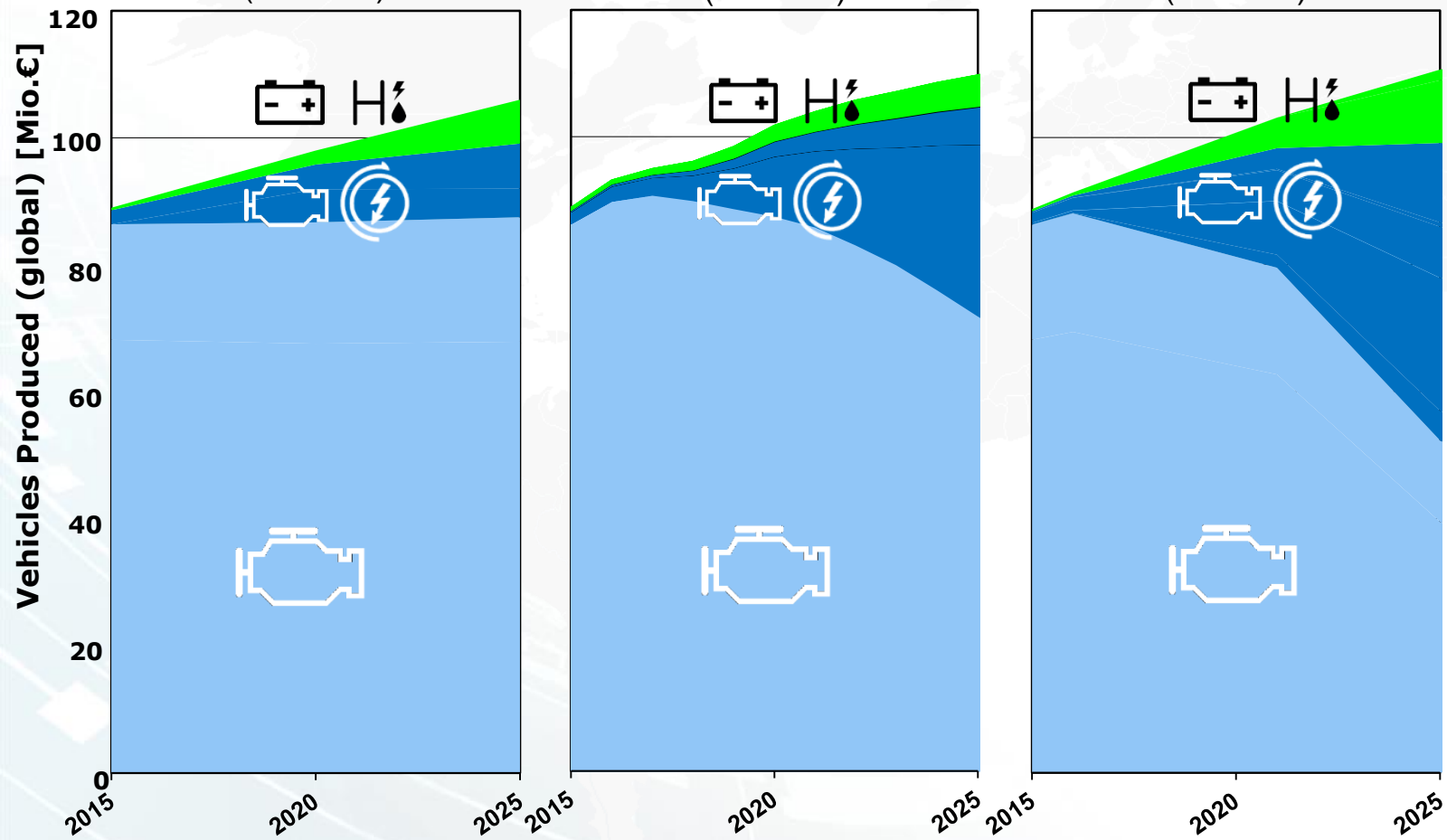
Global Technology Share Different Predictions



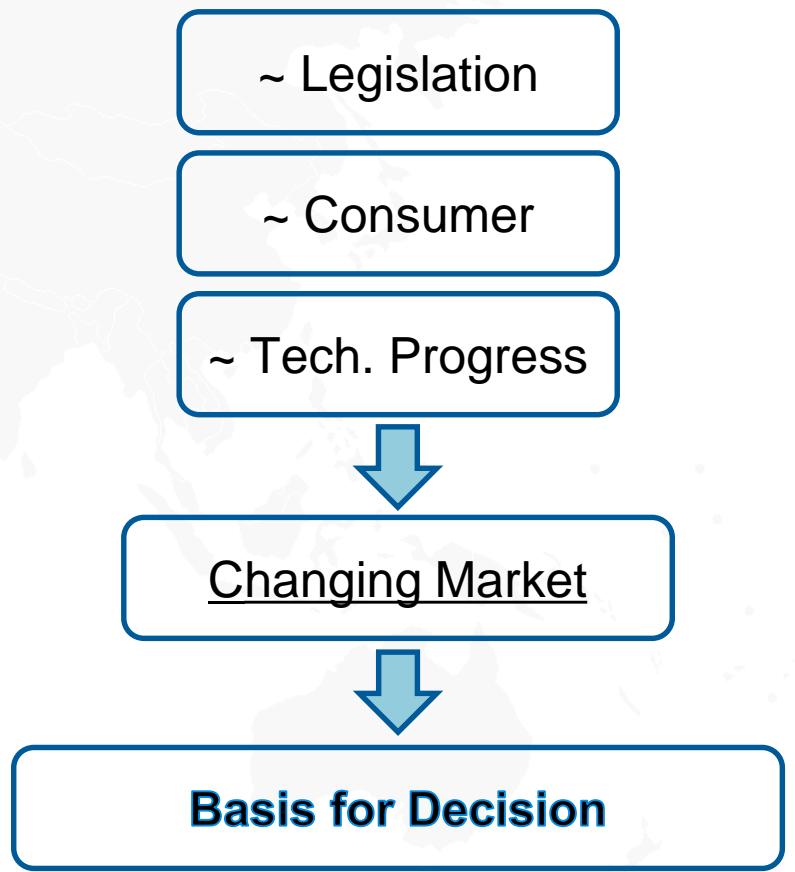
Bosch
(04/2017)

IHS
(10/2017)

AVL
(12/2017)



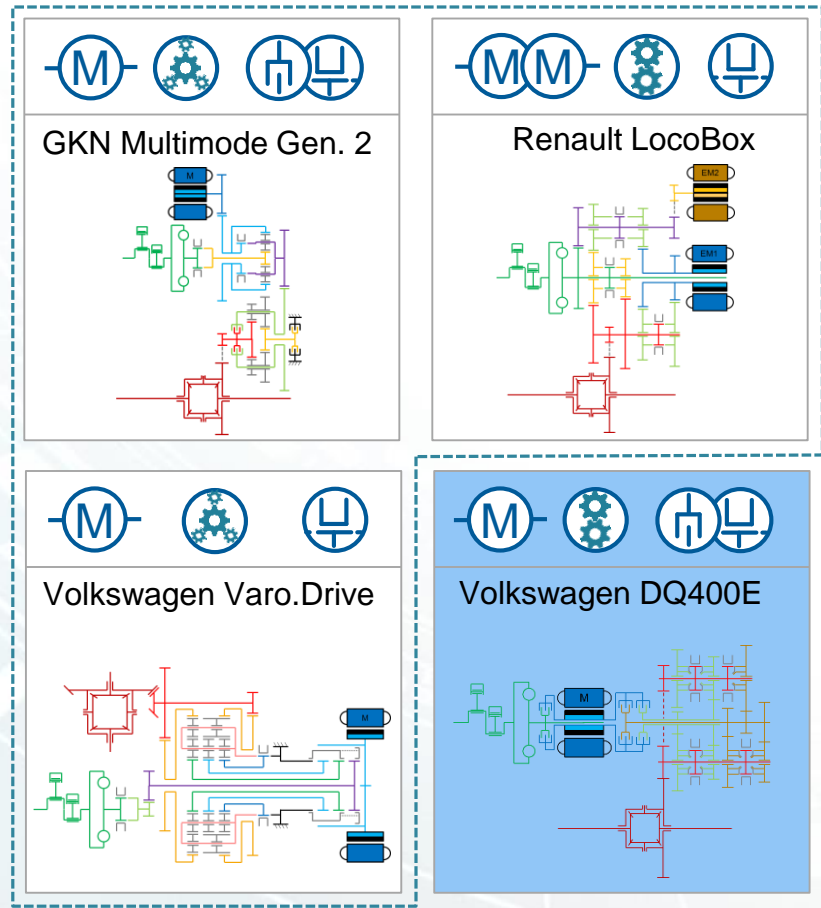
Boundary Conditions / Variations:



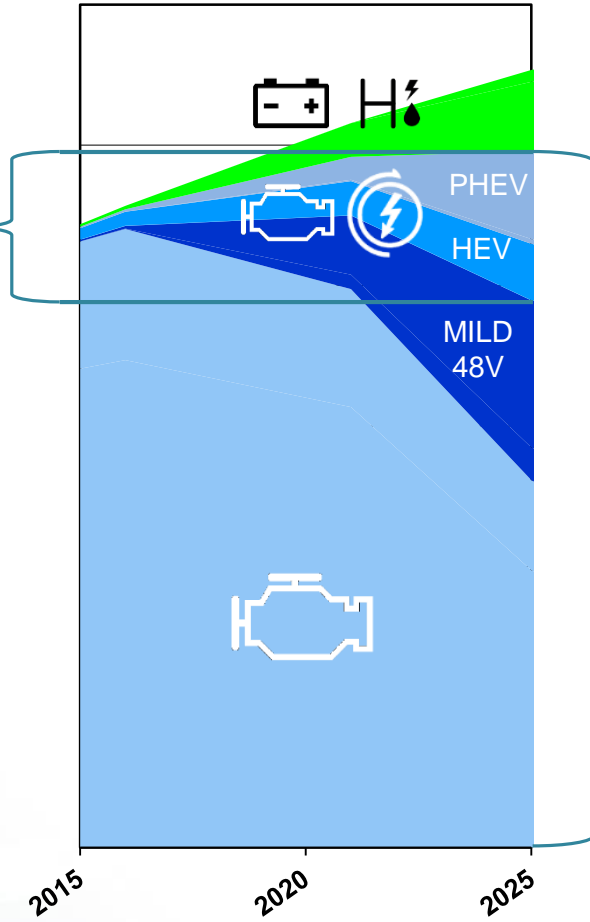
Global Technology Share possible solutions



DHT

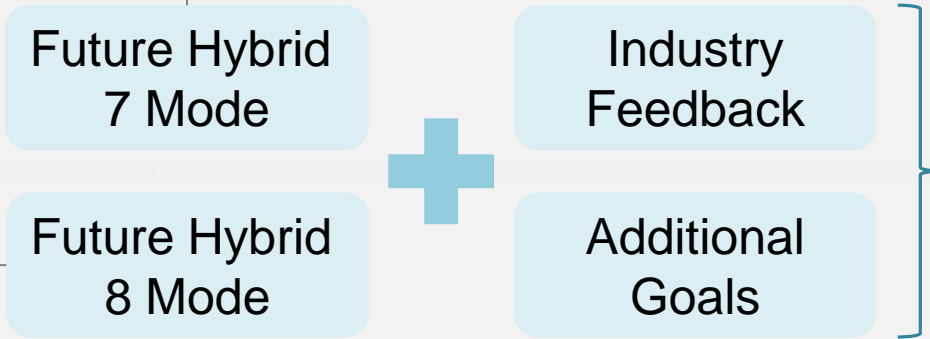
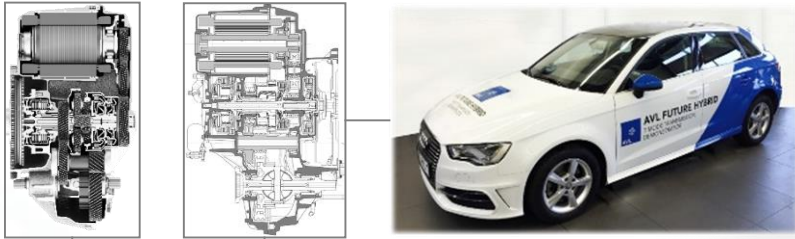


AVL
(12/2017)



PLAY IT SAFE!
go Modular
Future Hybrid X Mode

Development of the X Mode

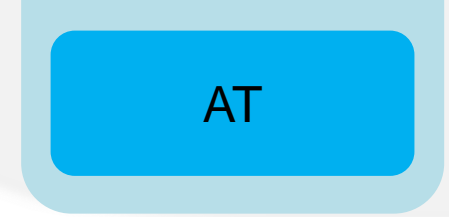
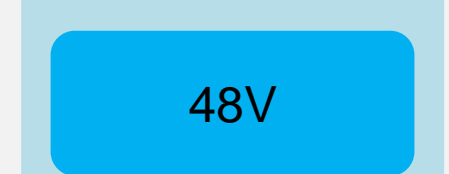
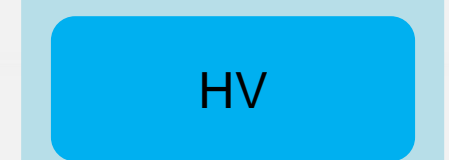
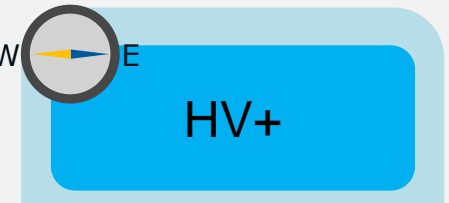
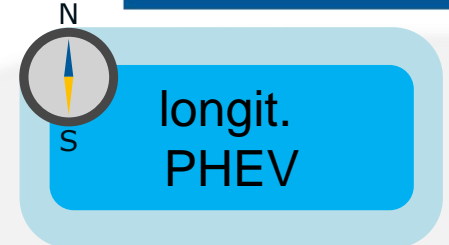


- + benefits
- + potential (AT)
- (hydraulic actuation)
- (integrated EM)

- + higher efficiency
- + smaller package
- + more common parts
- + modularity & flexibility**
- + cost focus**
- + driving comfort
- + etc.



- + search process
- + rating criteria
- + IP

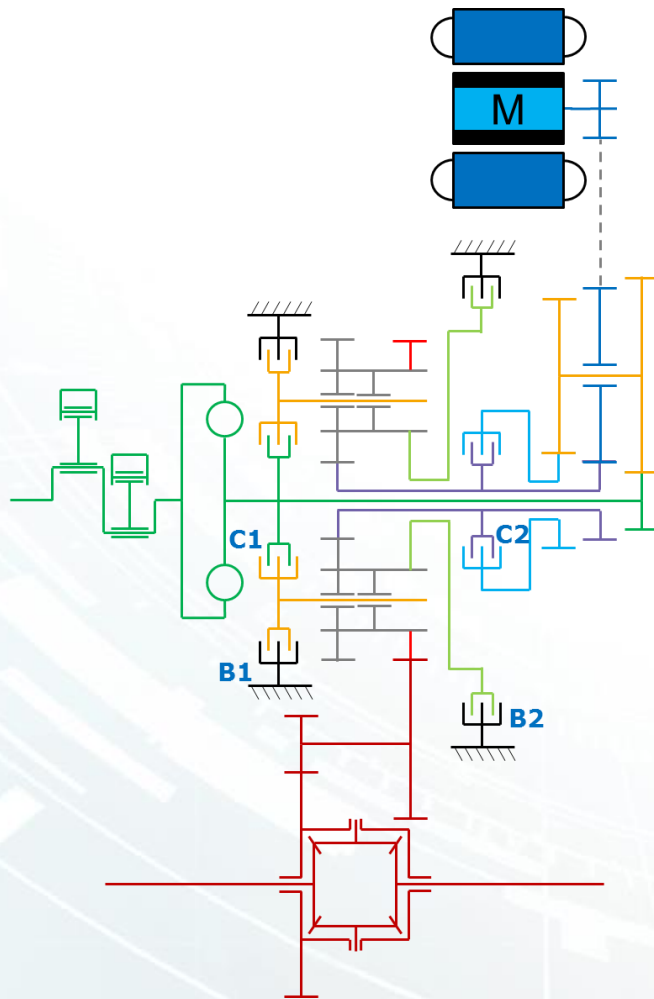


Modular Transmission Family



X Mode

Features: Future Hybrid X Mode Layout HV Variant (DHT)



Propulsion Source:

- Internal Combustion Engine (ICE)
- 1 Electric Machine (EM)
- up to E-Segment Vehicles

Features:

- Hybrid Functionality
- Low Number of Components
- Opportunity for Modularity (HV, 48V, AT)

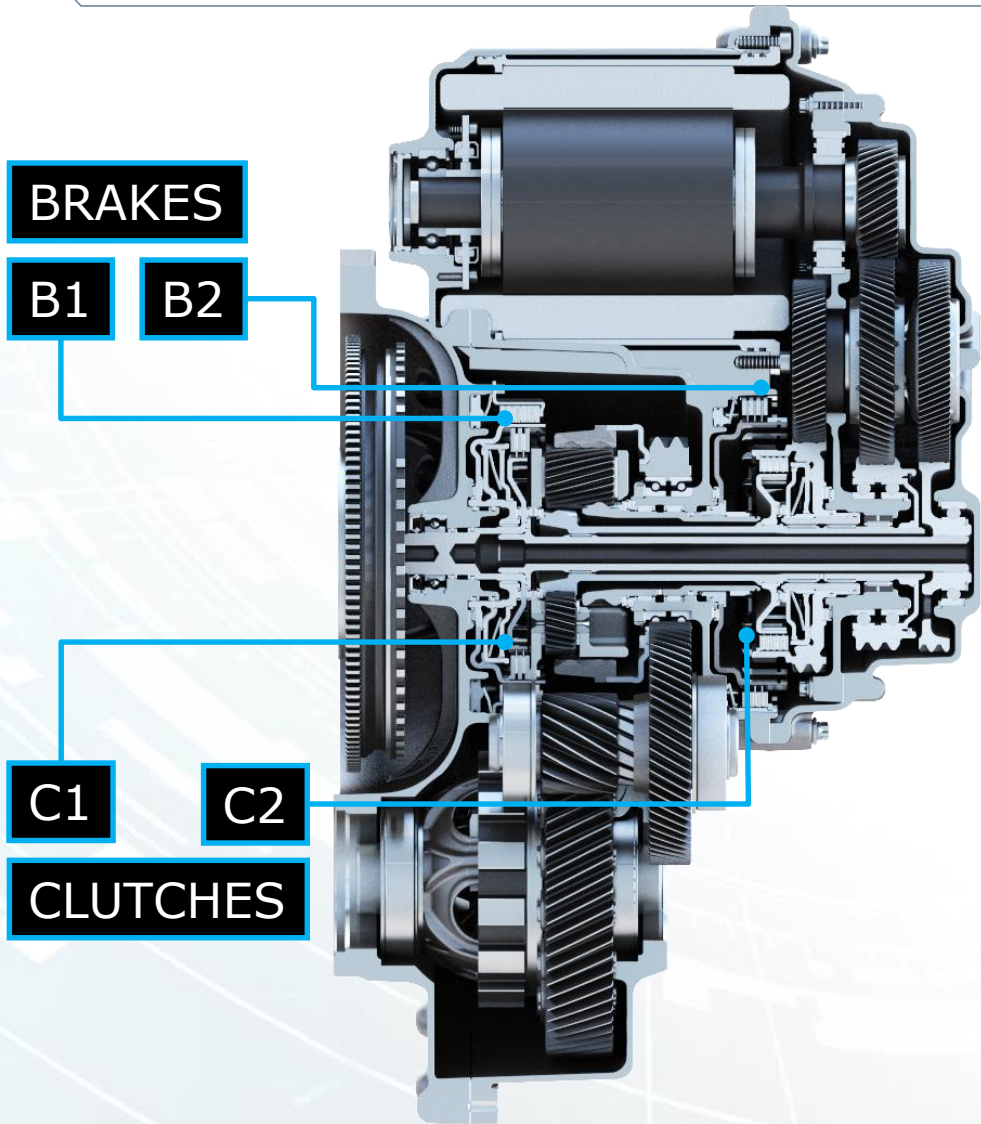
Transmission:

- Ravigneaux Planetary Gears Set
- Manipulating Idler
- Idler & Final Drive
- 2 Clutches
- 2 Brakes

Operation Modes: 7

- 4 ICE/Parallel-Hybrid Modes (PH)
- 2 Pure Battery Electric Modes (E)
- 1 Electric Continuously Variable Transmission Mode (ECVT)

Features: Future Hybrid X Mode Power Flow HV Variant (DHT)

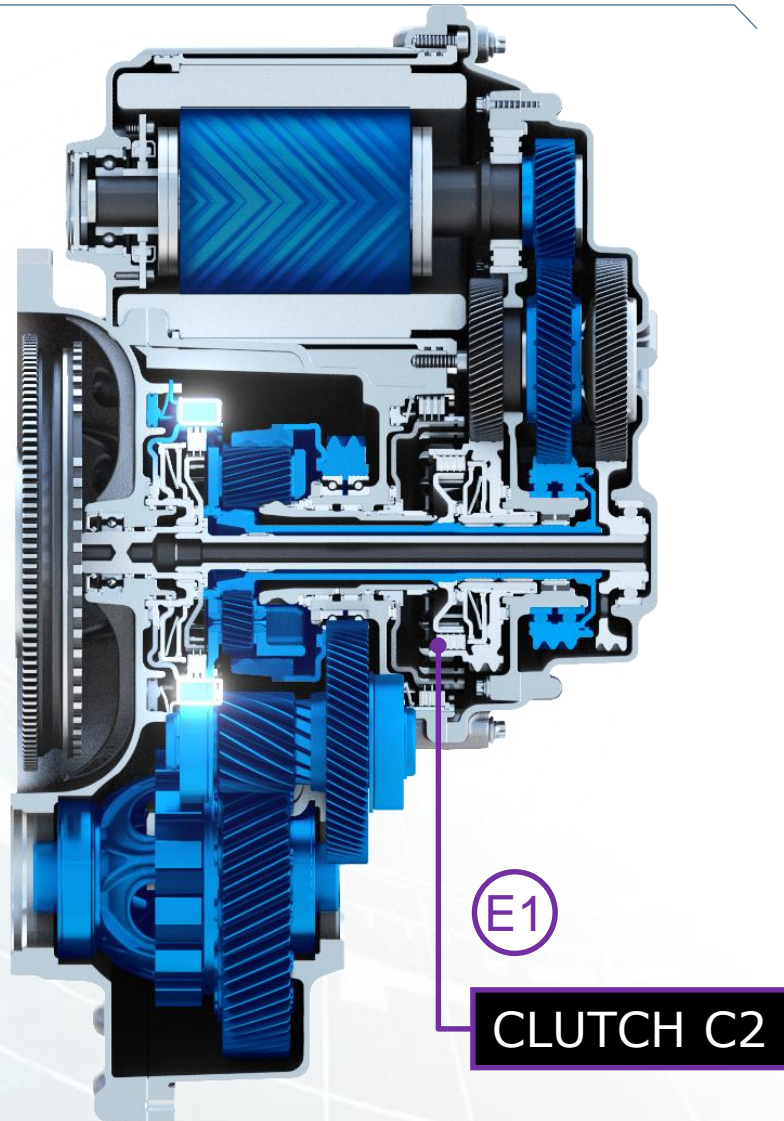


	BOOST	C1	C2	B1	B2
1 st PH	ICE EM		X	X	
2 nd PH	ICE EM		X		X
3 rd PH	ICE EM	X	X		
4 th PH	ICE EM	X			X
1 st E	EM			X	
2 nd E	EM				X
ECVT		X			
Standstill Charging			X		



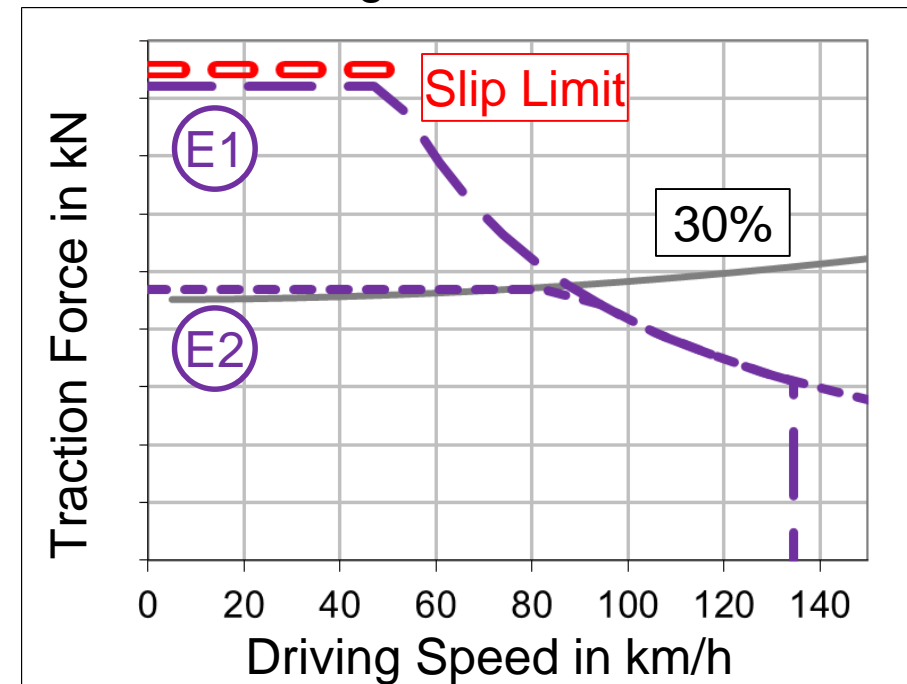
Design Example:
C-D-Segment Vehicle

Features: Future Hybrid X Mode Launch & Reversing HV Variant (DHT)

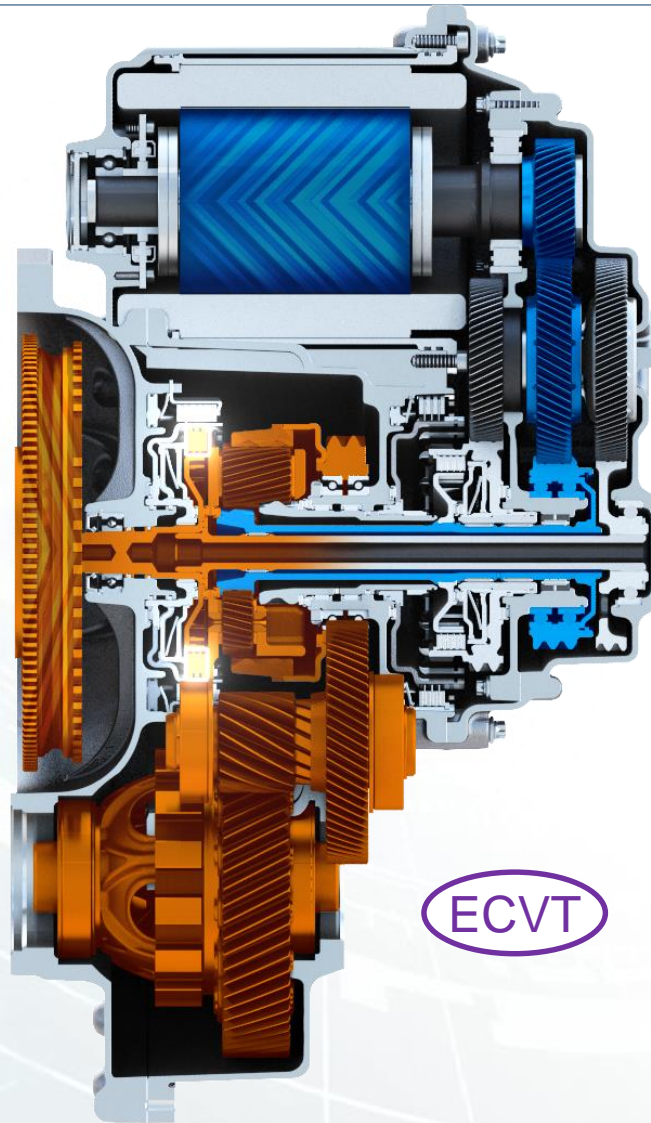


Electric Launch (C-D-Segment Vehicle):

- no need for: Mechanical Reverse Gear
 - EM Power ~ 110 kW (~200 Nm)
- ICE Cranking: via Clutch C2



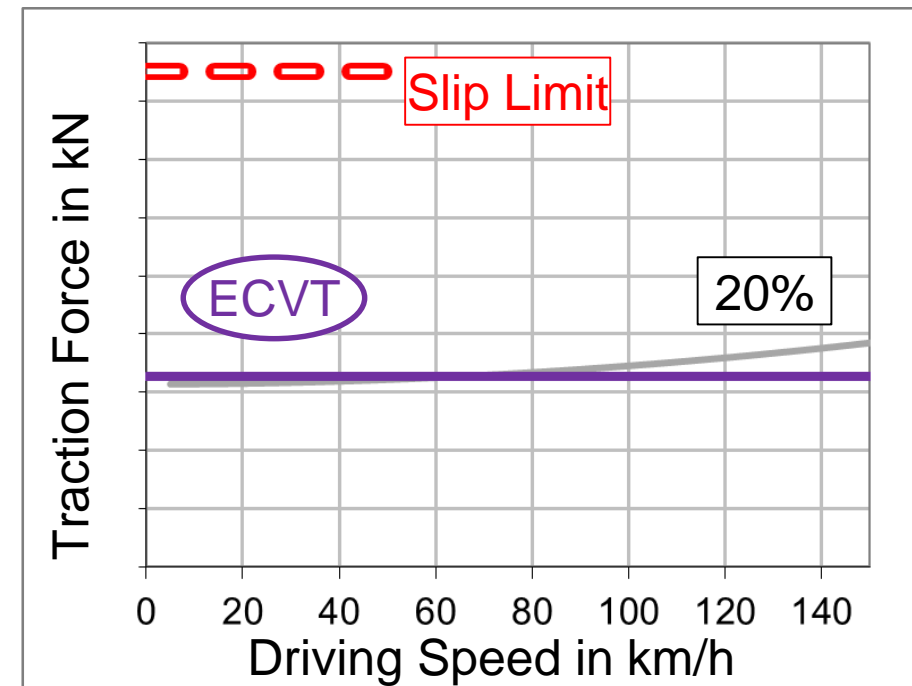
Features: Future Hybrid X Mode Launch HV Variant (DHT)



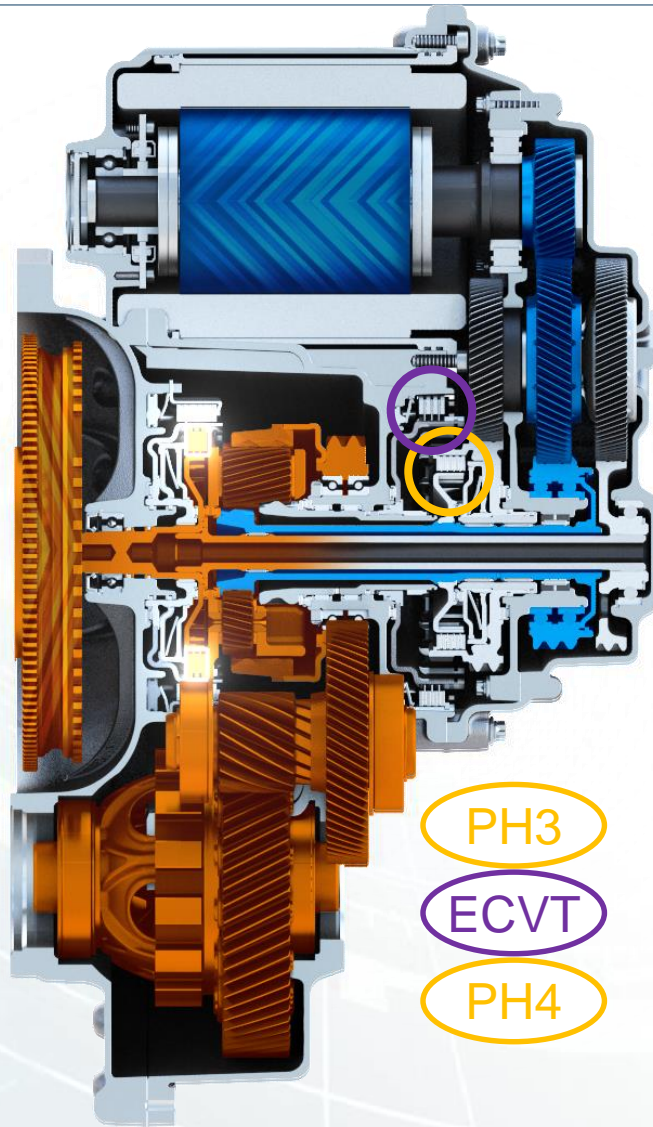
Low Battery (Stop/Go, Inclination <20%):

ECVT Launch, no Launch Clutch, 1 EM

- Max. Generated Power ~ 50 kW
 - ICE Power ~ 105 kW (~250 Nm)



Features: Future Hybrid X Mode Use of ECVT HV Variant (DHT)



PH3
ECVT
PH4

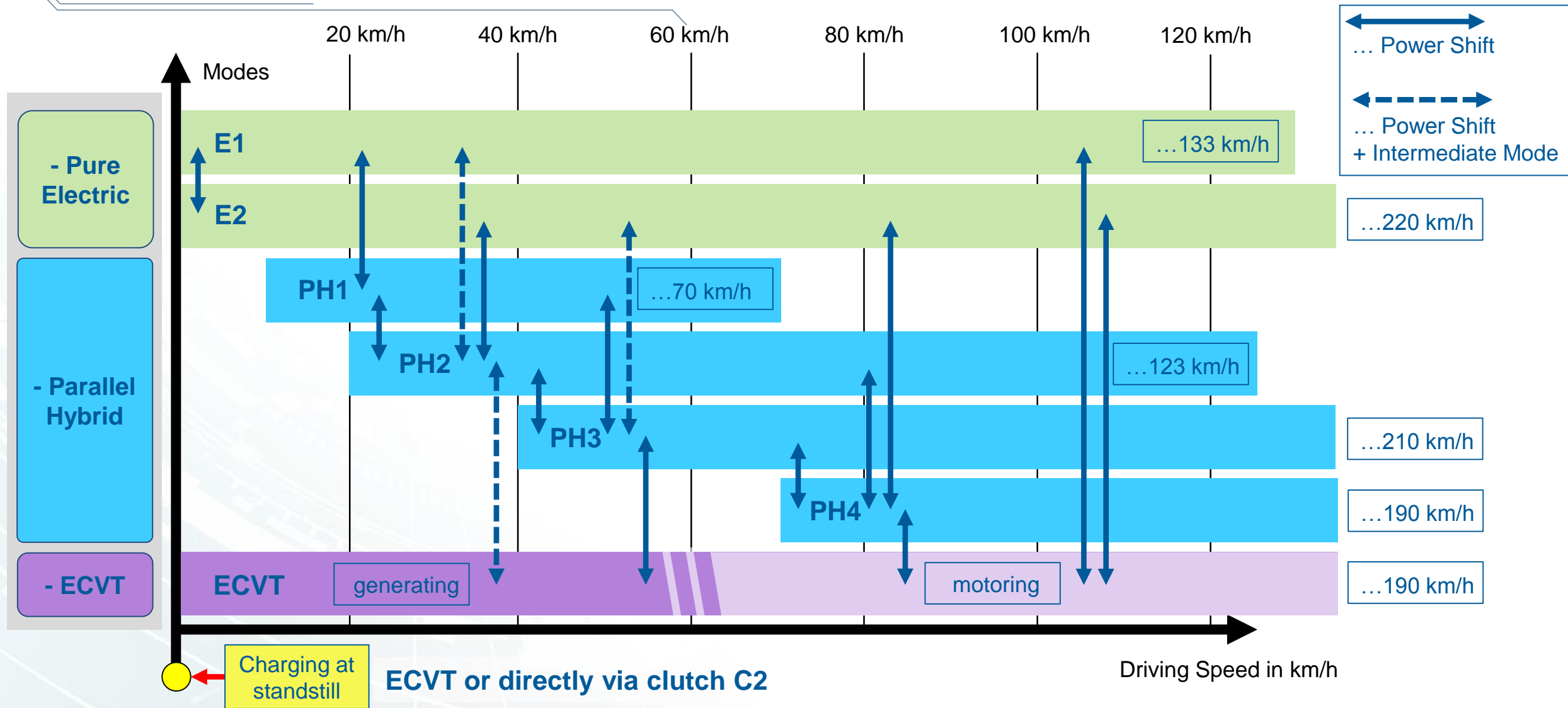
Dissipationless Shift Control:

- Generic Shift Control
- Increased Efficiency
- Better Durability of Clutches & Brakes

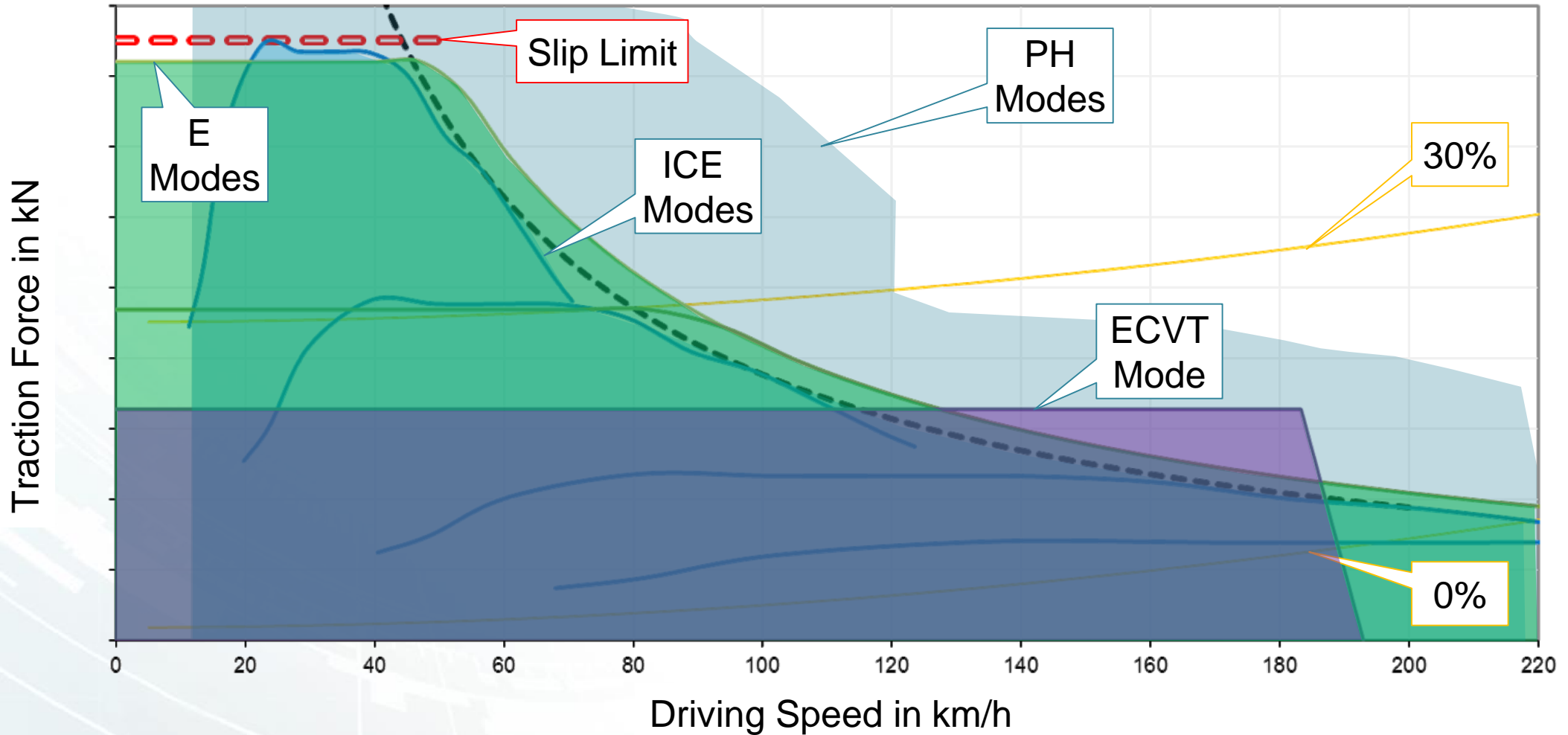
Example: PH3 → ECVT → PH4

		C1	C2	B1	B2
3 rd PH	ICE EM	X	X	$T_{C2} = 0 \text{ Nm}$	
	ECVT	X	$n_{B2} = 0 \text{ rpm}$		
4 th PH	ICE EM	X			X

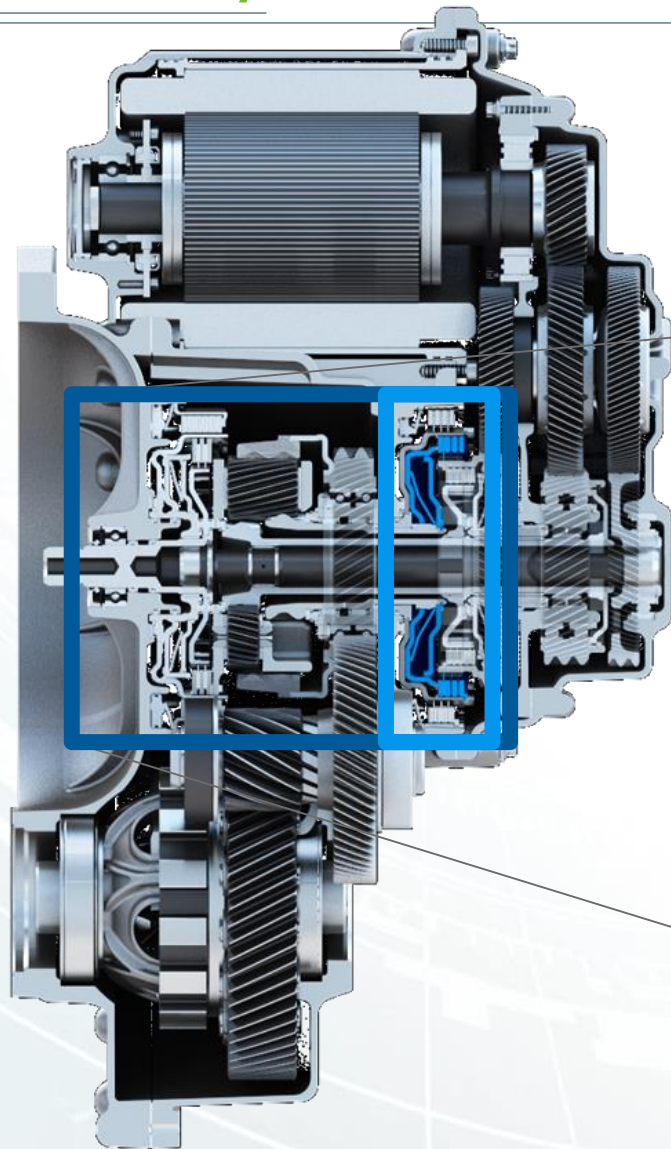
Features: Future Hybrid X Mode Mode Diagram HV Variant (DHT)



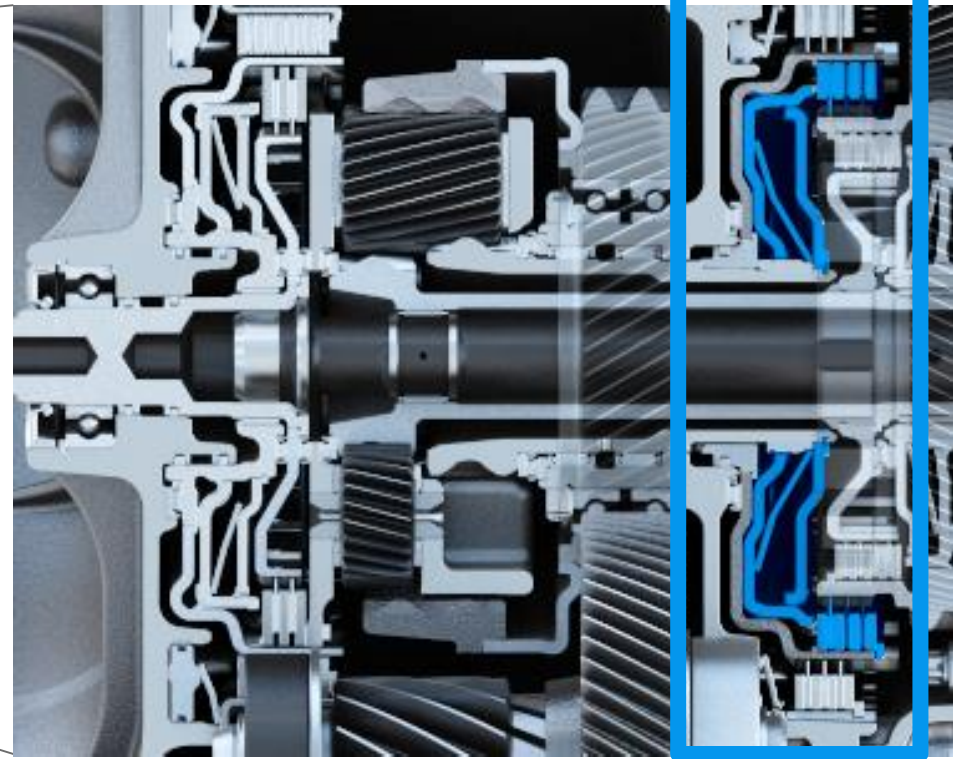
Features: Future Hybrid X Mode Traction Force HV Variant (DHT)



Benefits: Future Hybrid X Mode Modularity



**+ 2 Parallel Hybrid Forward Mode
+ 1 Reverse Mode**

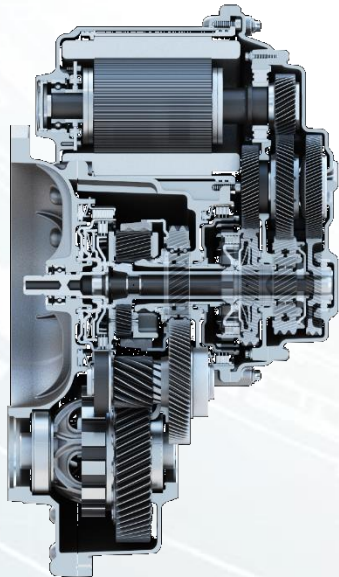


Benefits: Future Hybrid X Mode Modularity



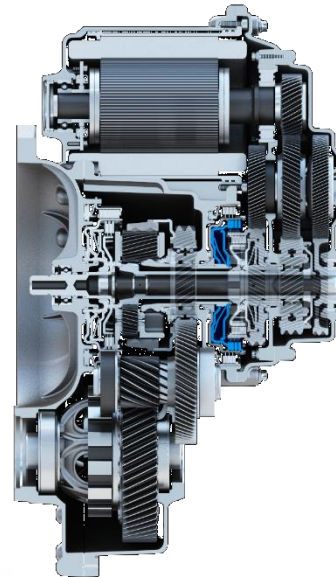
- HV

- 4 ICE/PH
- 2 EV
- 1 ECVT
- 1 Charge Stand.



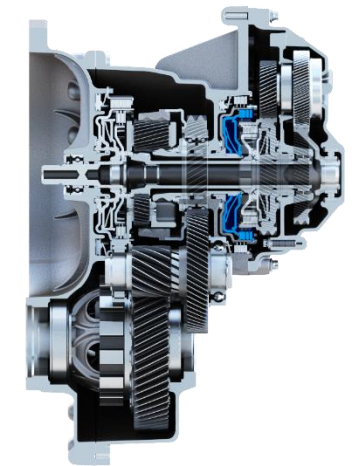
- HV+

- 6 ICE/PH + Rev.
- 2 EV
- 2 ECVT
- 1 Charge Stand.



- 48V

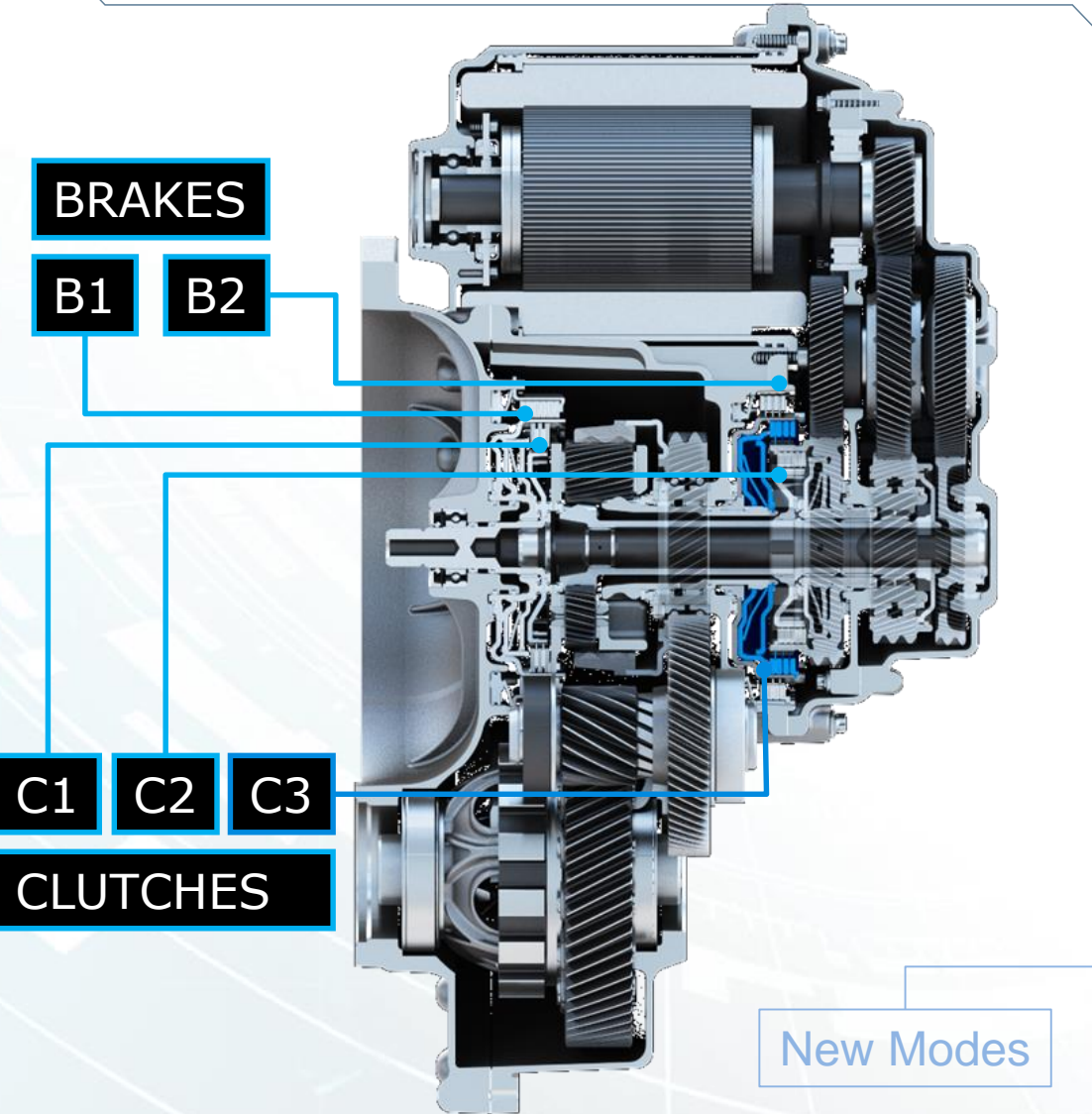
- 6 ICE/PH + Rev.
- 2 EV
- 1 Charge Stand.



- AT

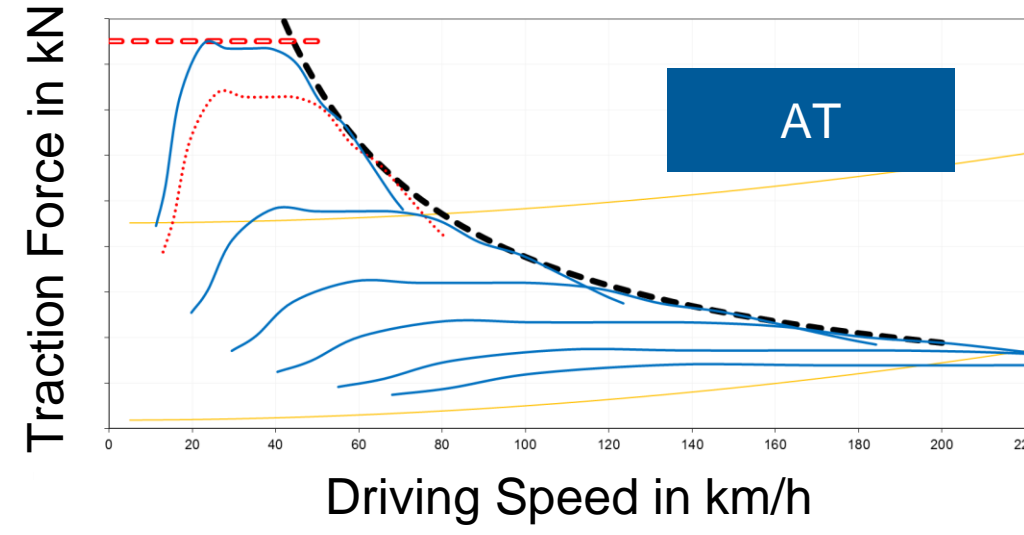
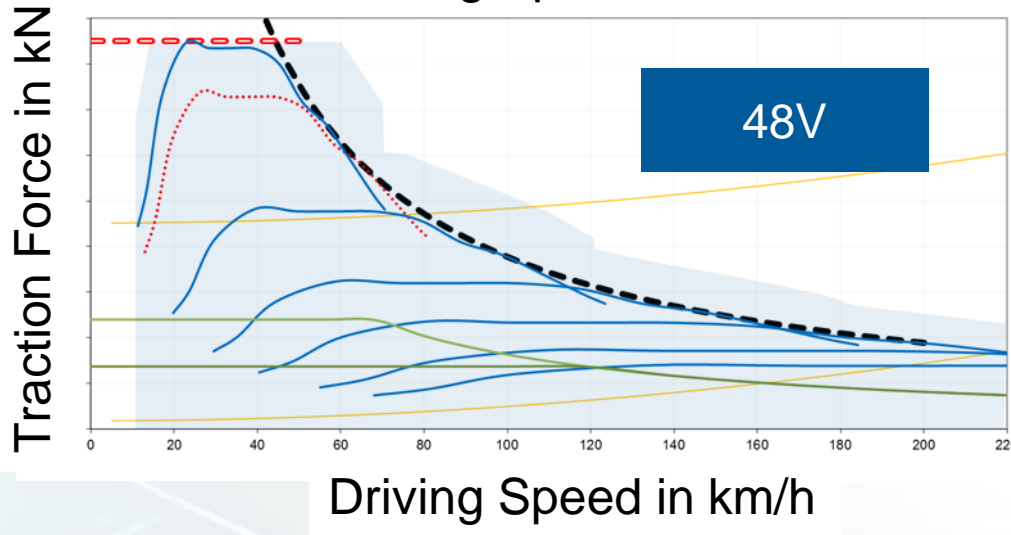
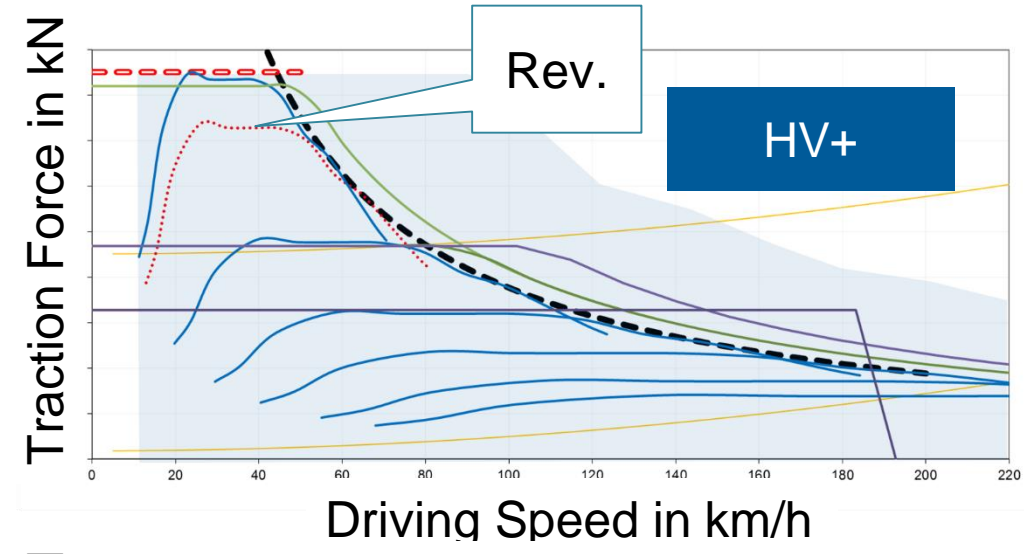
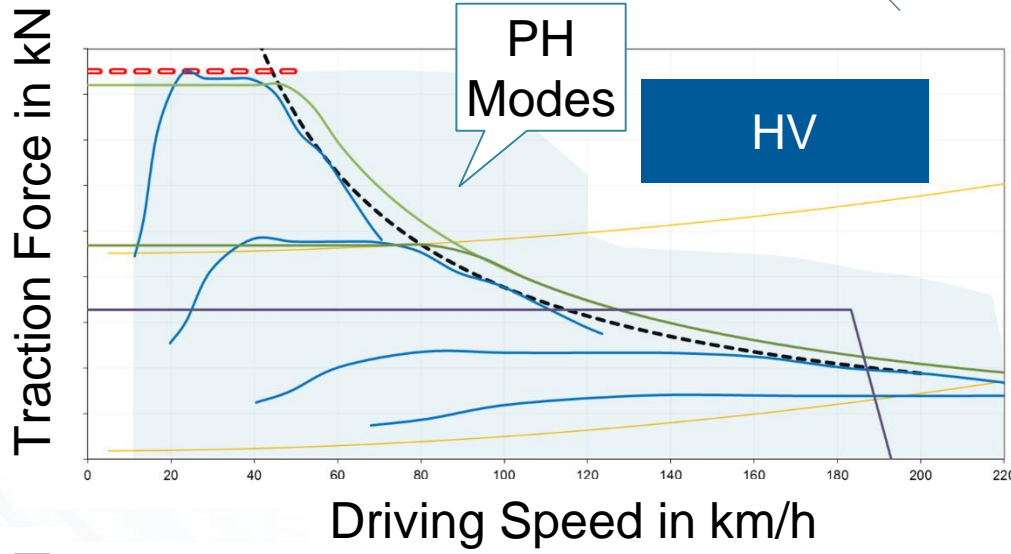
- 6 ICE + Rev.
- (Launch Clutch B1 or C2/C3 considered)

Benefits: Future Hybrid X Mode Extended Shift Table



	BOOST	C1	C2	C3	B1	B2
R PH	ICE EM			X	X	
1st PH	ICE EM		X		X	
2nd PH	ICE EM		X			X
3rd PH	ICE EM		X	X		
4th PH	ICE EM	X	X			
5th PH	ICE EM	X		X		
6th PH	ICE EM	X				X
1st E	EM				X	
2nd E	EM					X
1st ECVT		X				
2nd ECVT				X		
Standstill Charging			X			

Benefits: Future Hybrid X Mode Traction Force HV/HV+/48V/AT



Benefits: Future Hybrid X Mode Package HV/HV+/48V/AT



Layout Example:

(C-D-Segment Vehicle)

ICE ~ 105 kW (~250 Nm)

EM (HV) ~ 110 kW (~200 Nm)

EM (48V) ~ 15-25 kW (~45 Nm)

Future Hybrid X Mode HV+:

Length < 380 mm (AT: <365 mm)

Height < 500 mm (AT: <390 mm)

Width < 540 mm (AT: <520 mm)

Weight < 126 kg (AT: <77 kg)

similar P2-6DCT:

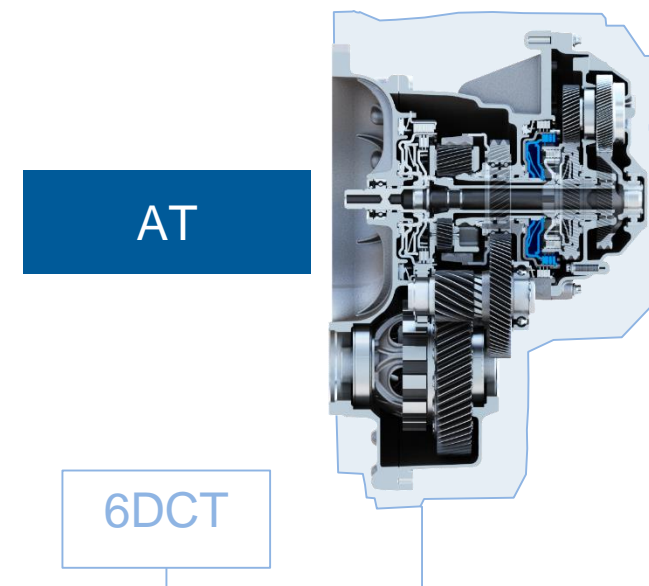
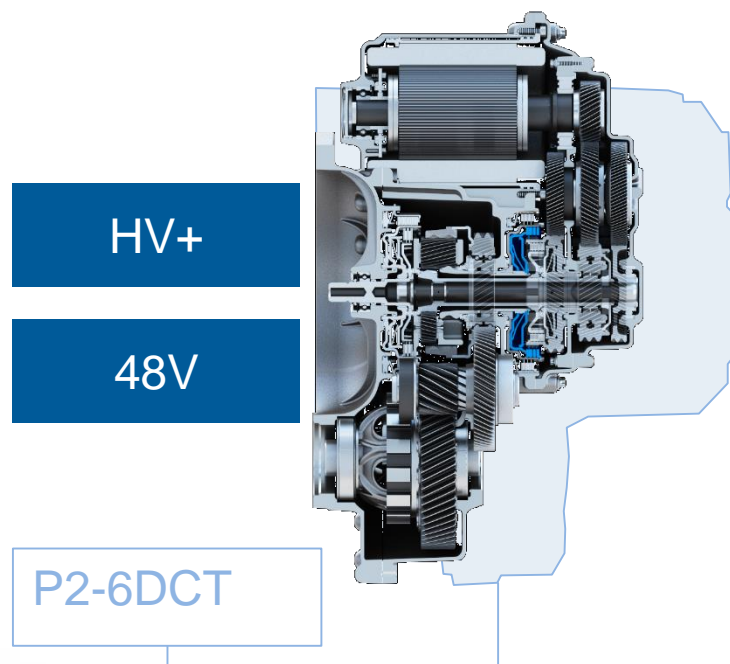
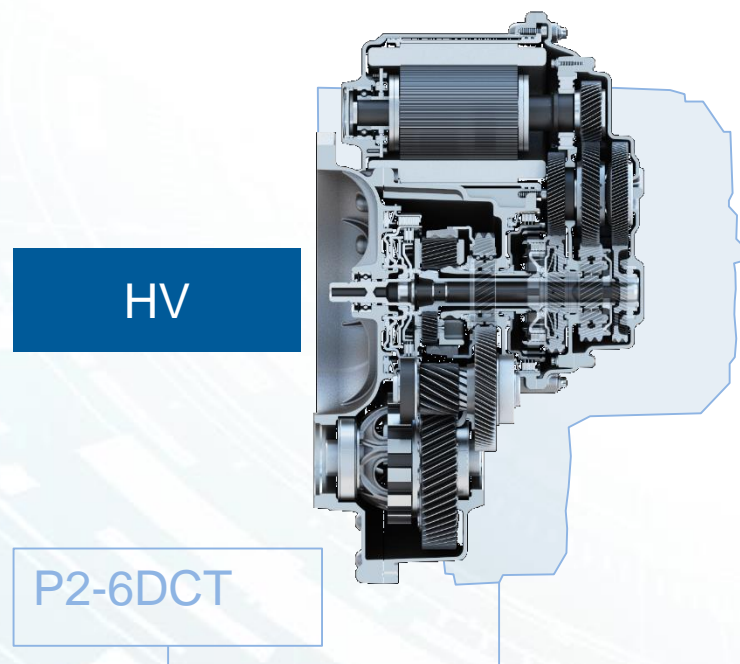
Length < 490 mm (6DCT: <380 mm)

Height < 425 mm (6DCT: <425 mm)

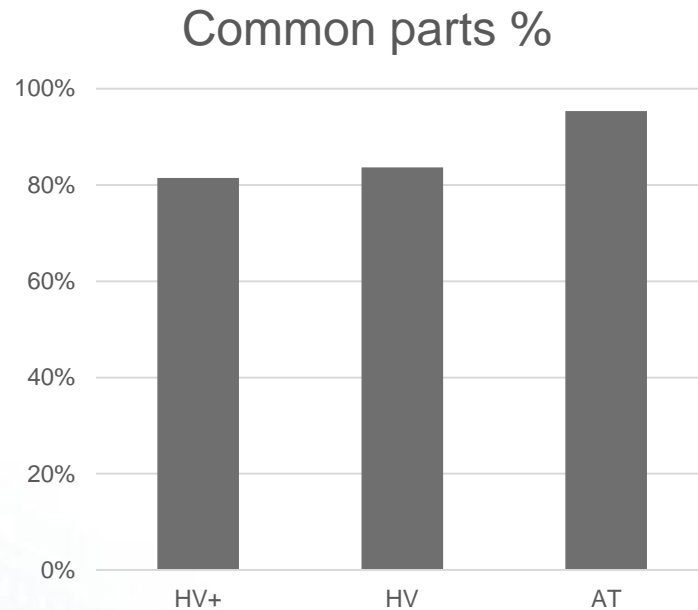
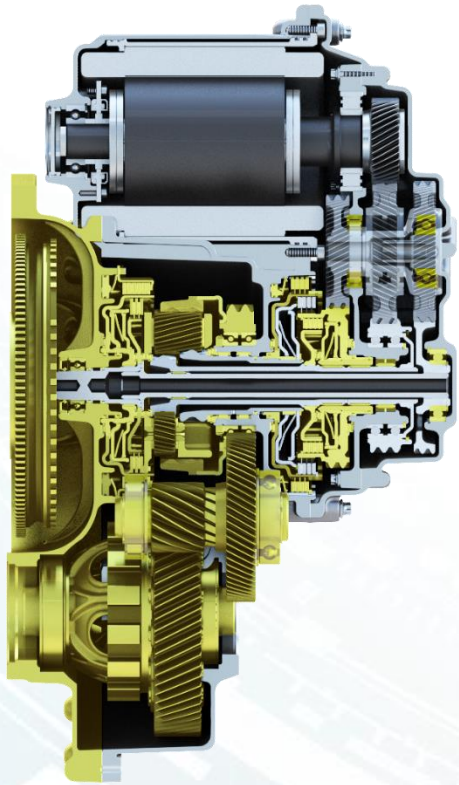
Width < 520 mm (6DCT: <520 mm)

Weight < 125 kg (6DCT: <71 kg)

Benefits: Future Hybrid X Mode Package HV/HV+/48V/AT



Benefits: Future Hybrid X Mode Modularity and its Opportunities



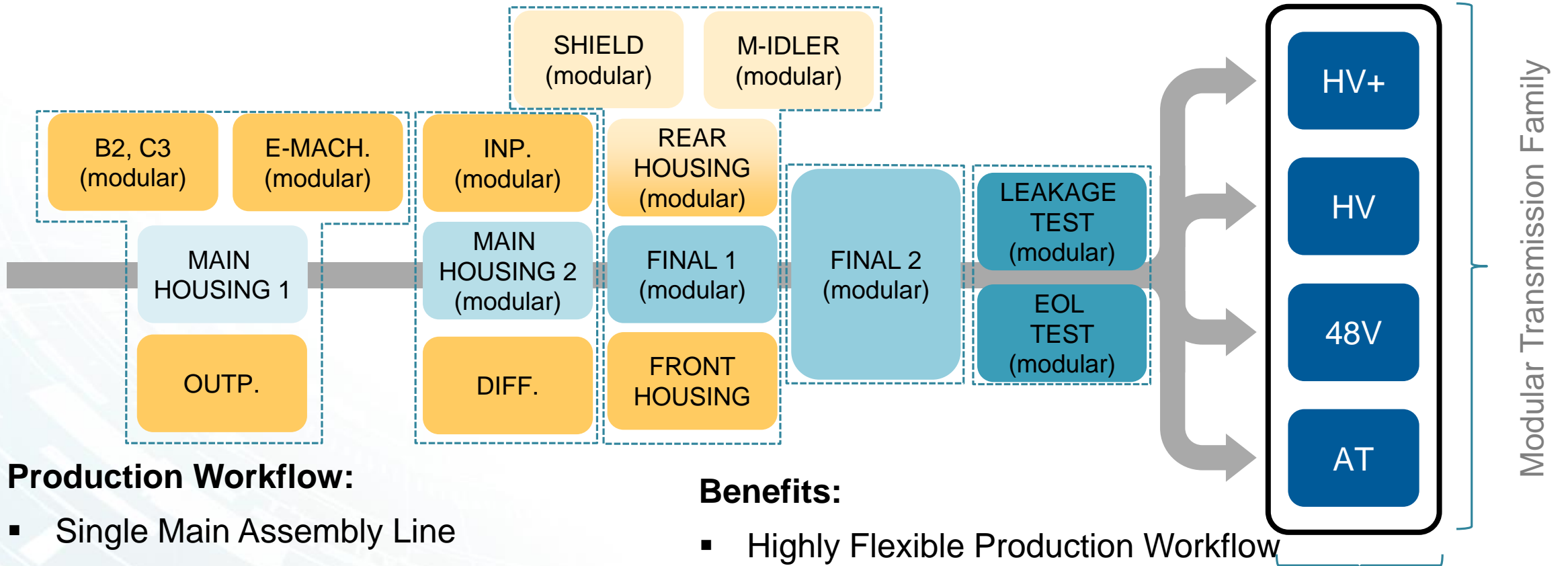
Core Transmission & Modules:

- High percentage of Common Parts: Clutches/Brakes (C1, C2, B1, B2), Planet Carrier & Rim, Final Drive & Idler, Front Housing
- Interchangeable Modules for Variants
- Common Development Process for Core & Modules
- Flexible Production & Assembly

	HV+	HV	AT
Total part number in Variants	226	220	193
Part number in Core Module	184	184	184
Common parts %	81%	84%	95%

ONE Core Transmission for all Variants
(HV+/HV/48V/AT)

Benefits: Future Hybrid X Mode Modular Production



Production Workflow:

- Single Main Assembly Line
- Modular Sub-Assemblies
- Quick Changeover Times or Mixed-Model Assembly

Benefits:

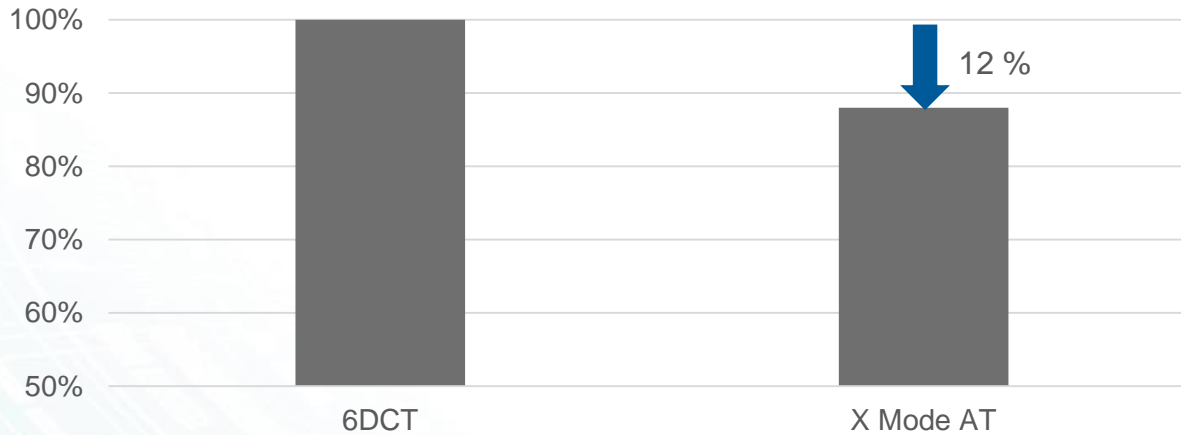
- Highly Flexible Production Workflow
- Fast Adjustment of Volume Split

**→ Lowering Risk
Posed by Changing Markets**

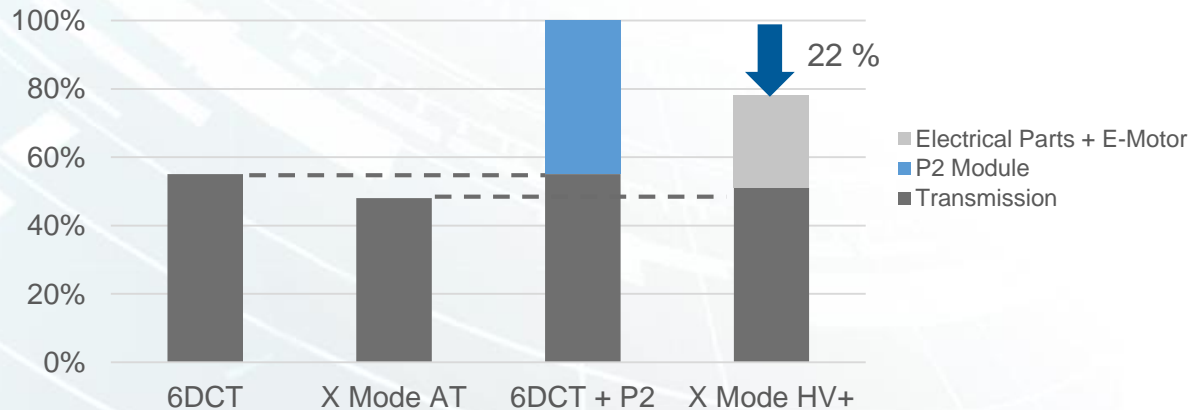
Benefits: Future Hybrid X Mode Modularity & Volume Split



Cost comparison between 6DCT and Future Hybrid X Mode AT



Cost comparison between 6DCT and Future Hybrid X Mode



Production Scenario:

- Overall Units Produced p.a. : 400.000 Units
- Production Duration: 7 years
- Total Units after 7 years: 2.800.000

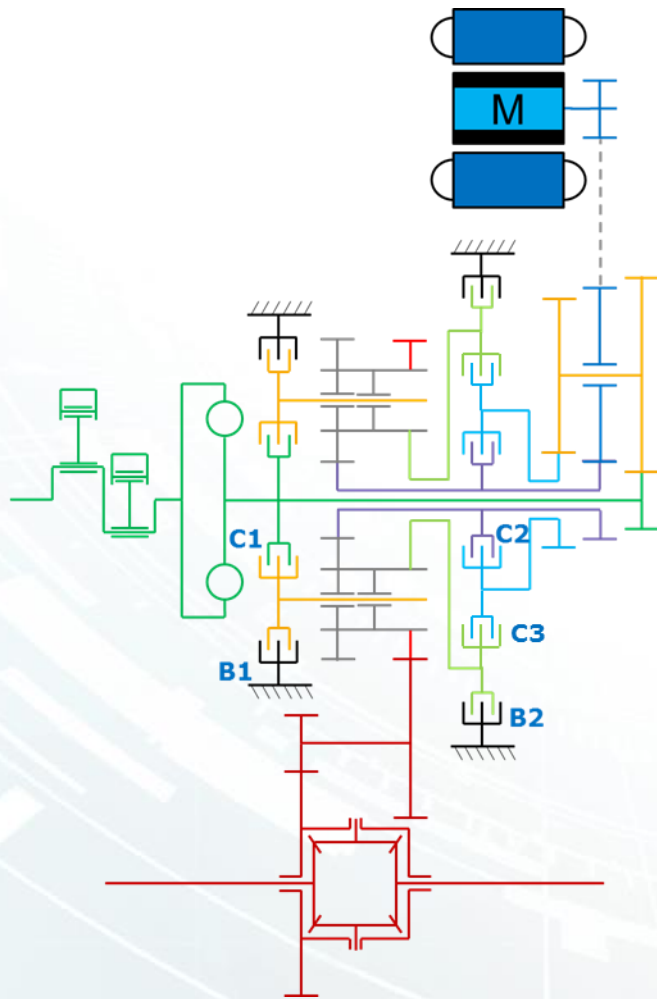
Volume Split:

- AT: 52 %
- 48V: 26 %
- HV/HV+: 22 %

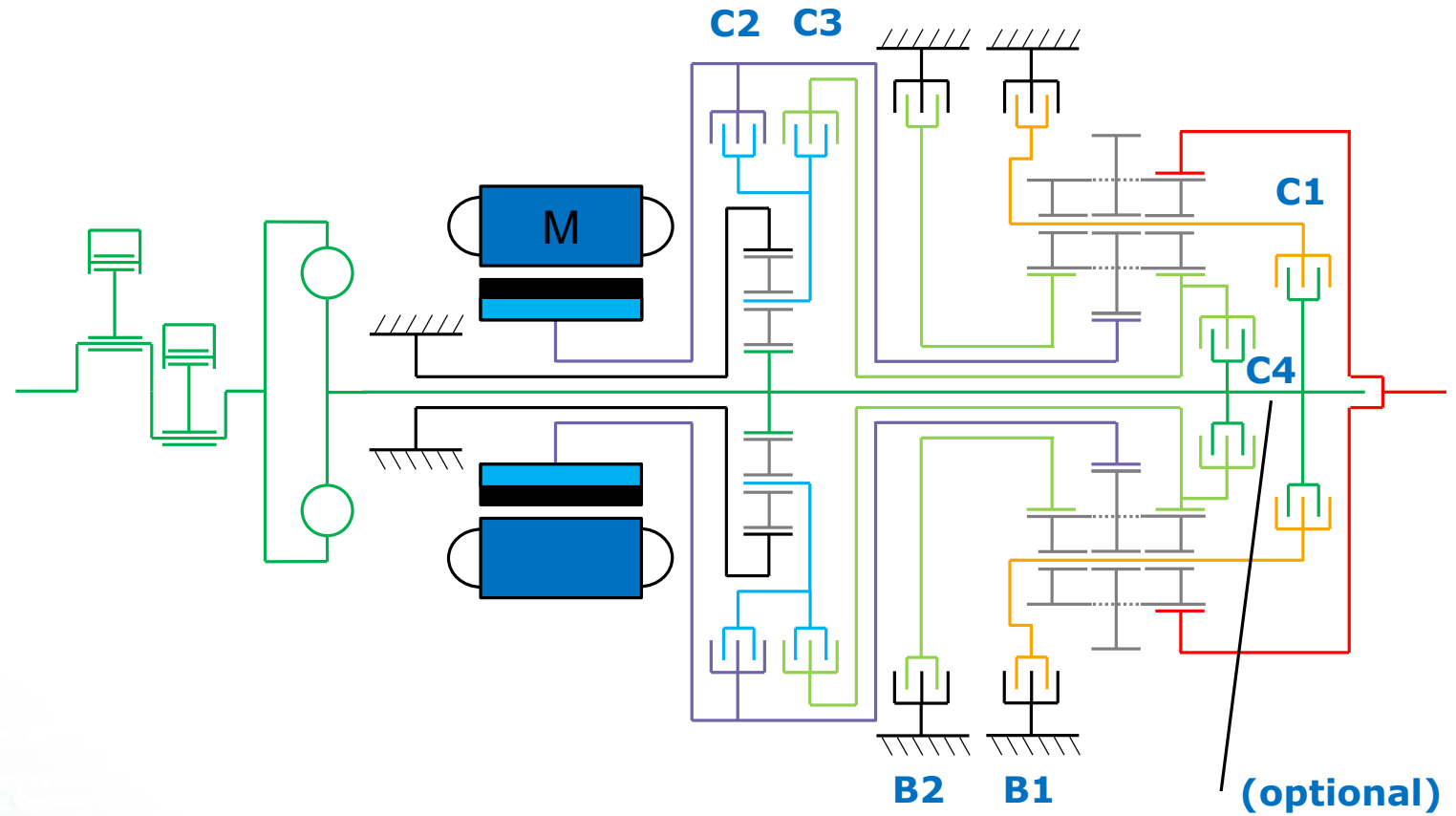
Results Future Hybrid X Mode:

- AT lowered cost by 12% compared to a similar 6DCT
- HV+ lowered cost by 22% compared to a similar 6DCT with P2 add-on Module

Recent Development: Longitudinal X Mode Hybrid Transmission



transverse

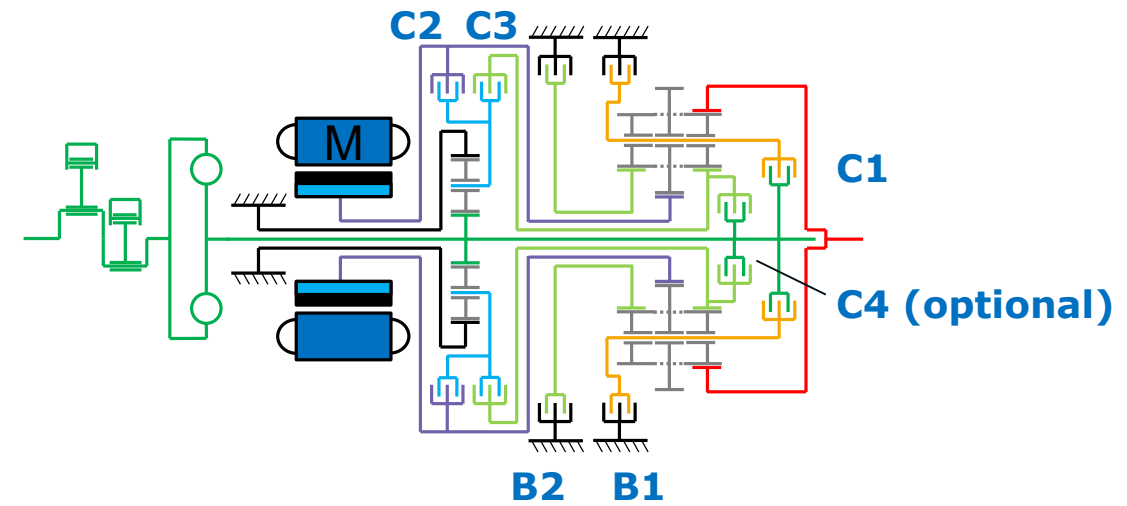


longitudinal

Recent Development: Longitudinal X Mode Hybrid Transmission

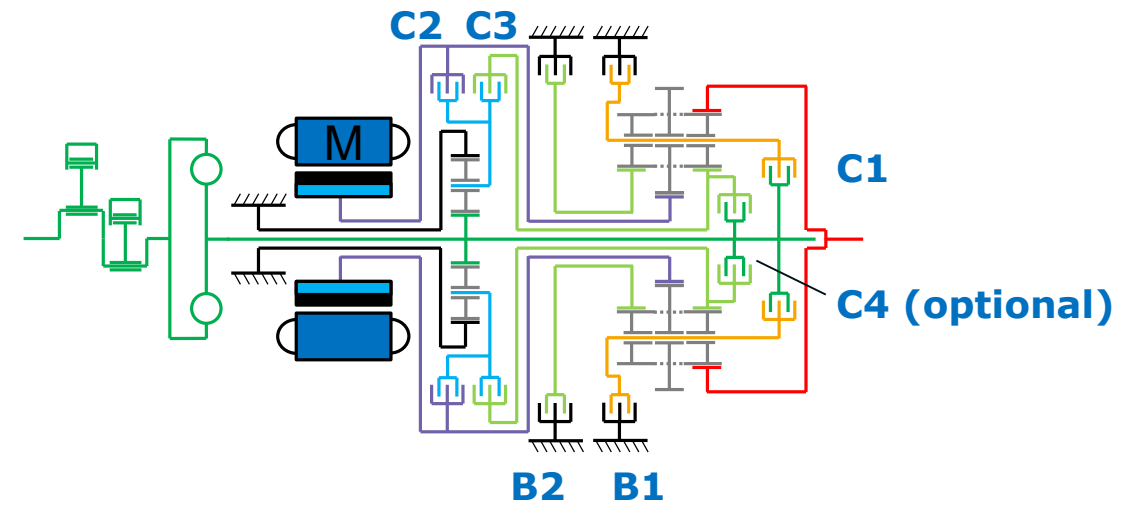
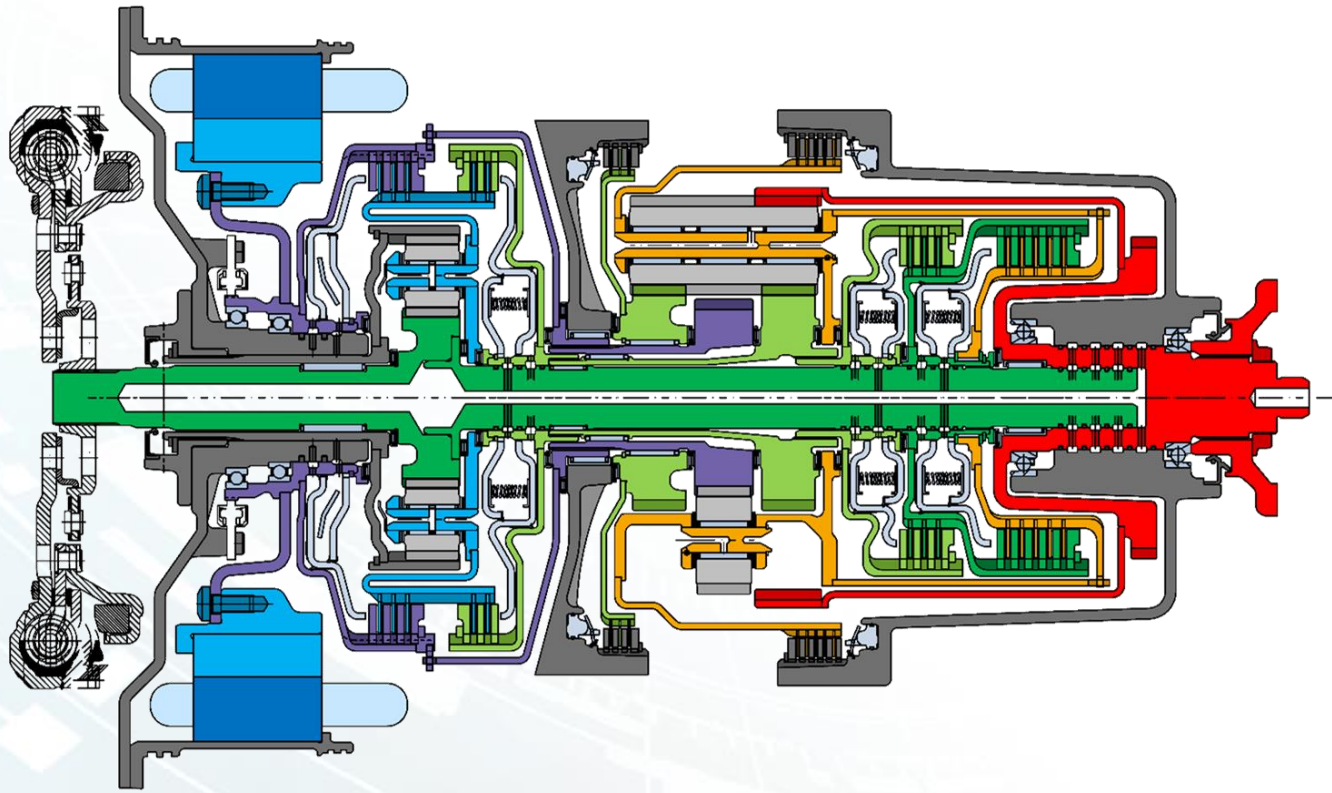


	C1	C2	C3	C4	B1	B2
R1 PH ICE EM			X		X	
R2 PH ICE EM				X	X	
1 st PH ICE EM		X			X	
2 nd PH ICE EM		X				X
3 rd PH ICE EM		X	X			
4 th PH ICE EM		X		X		
5 th PH ICE EM	X	X				
6 th PH ICE EM	X			X		
7 th PH ICE EM	X		X			
8 th PH ICE EM	X					X



	C1	C2	C3	C4	B1	B2
1 st E EM					X	
2 nd E EM						X
1 st ECVT	X					
2 nd ECVT			X			
3 rd ECVT				X		
Standstill Charging		X				

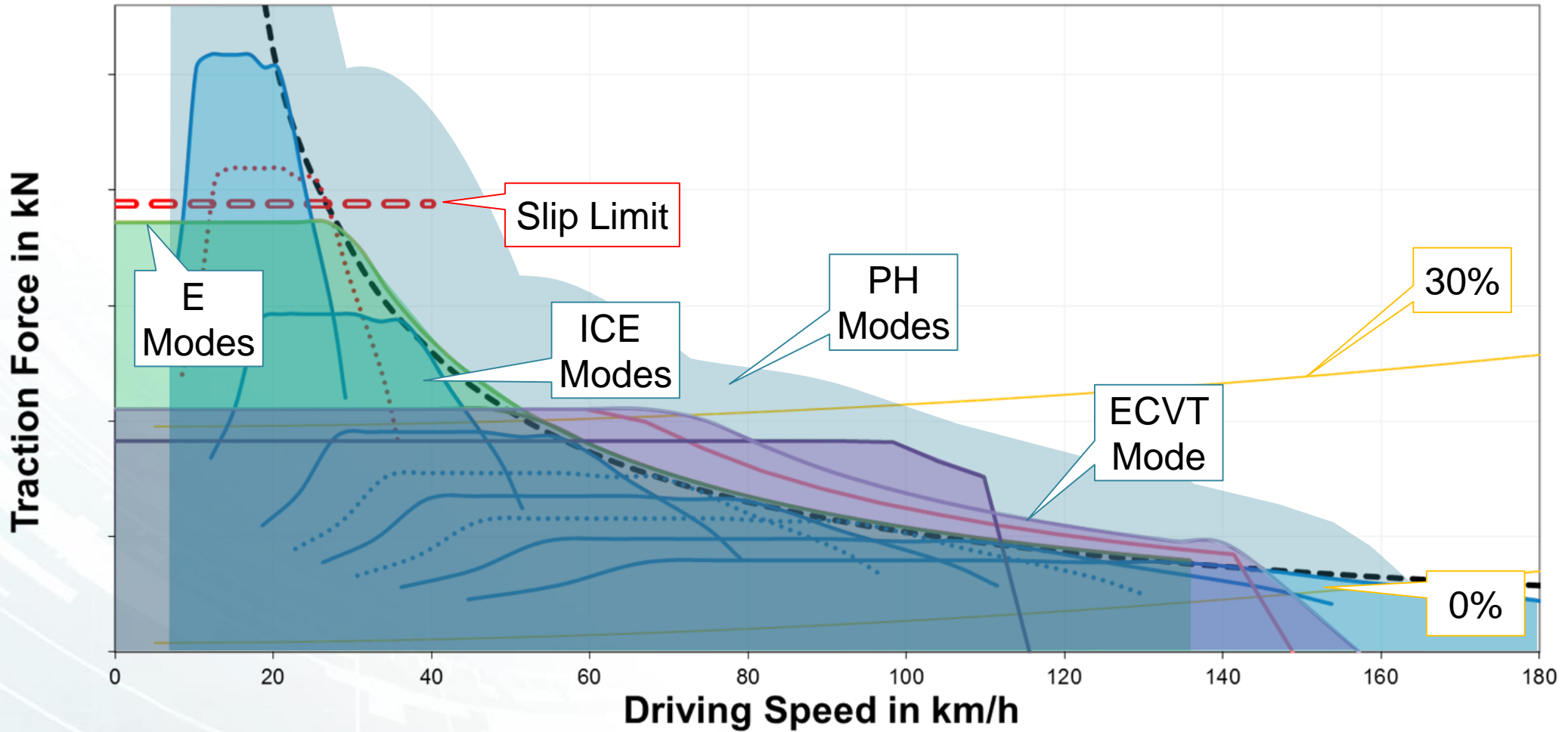
Recent Development: Longitudinal X Mode Hybrid Transmission



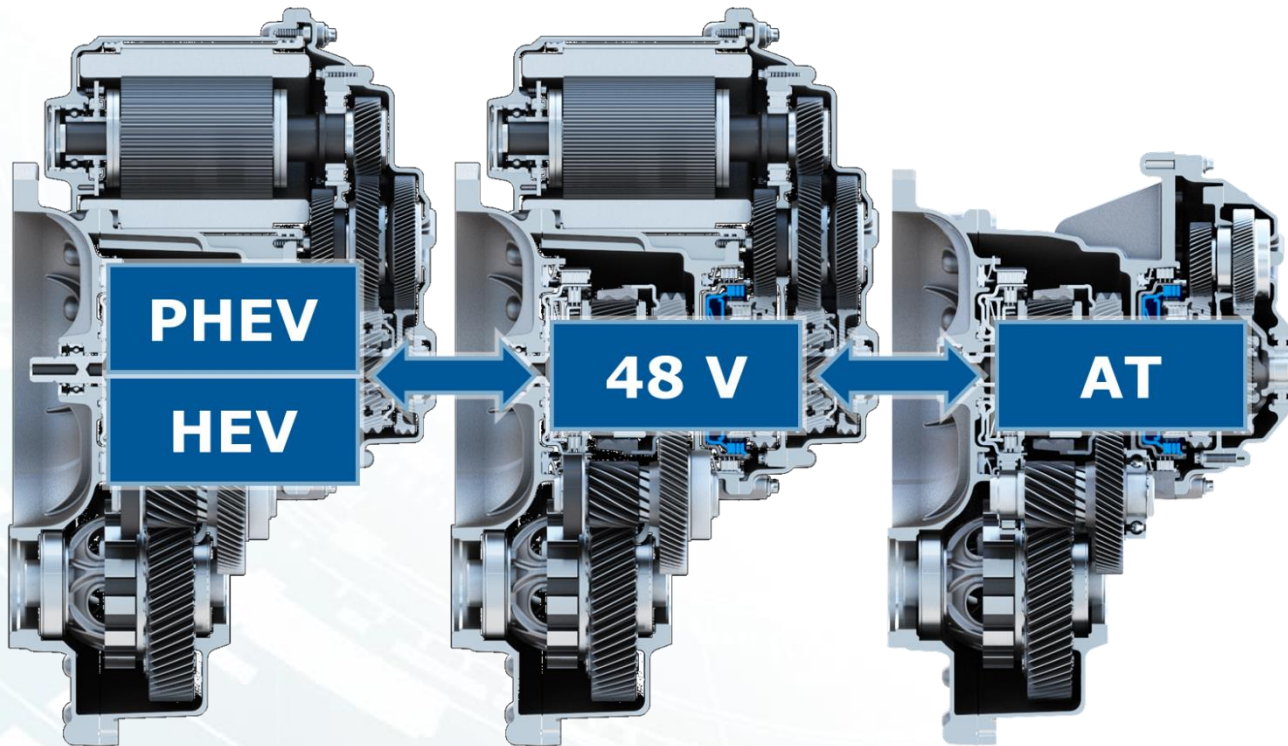
Layout Variant:

- for mid-sized to semi-full-sized SUVs
- transmission spread: 9.3
- transmission length: < 650 mm

Recent Development: Longitudinal X Mode Hybrid Transmission



Future Hybrid X Mode Summary



Transmission Family on one Assembly Line:

- Outstanding DHT for HV applications
- Modular Concept for all Levels of Electrification
- Flexible & Low Cost



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go Modular

Thank You



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