evs 27

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Efficiency Enhancement of a New Two-Motor Hybrid System

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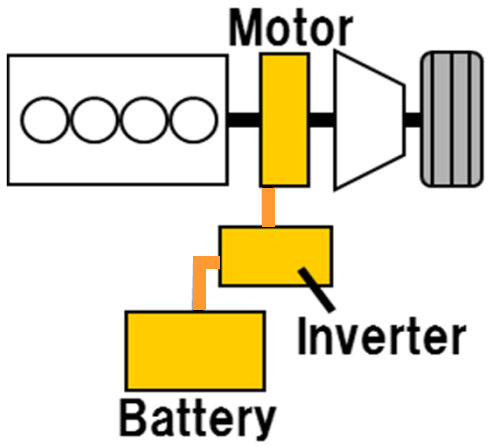
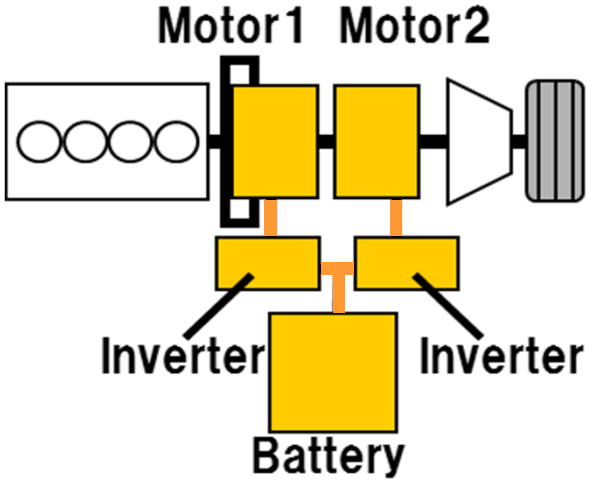
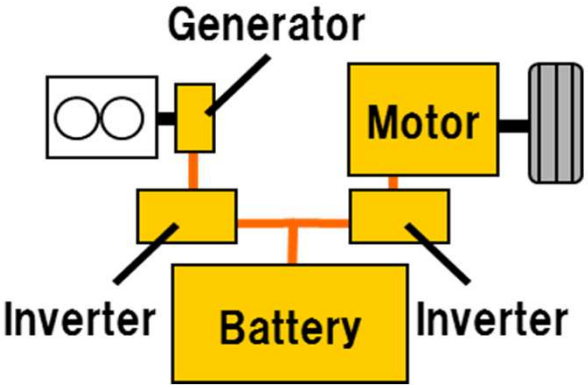
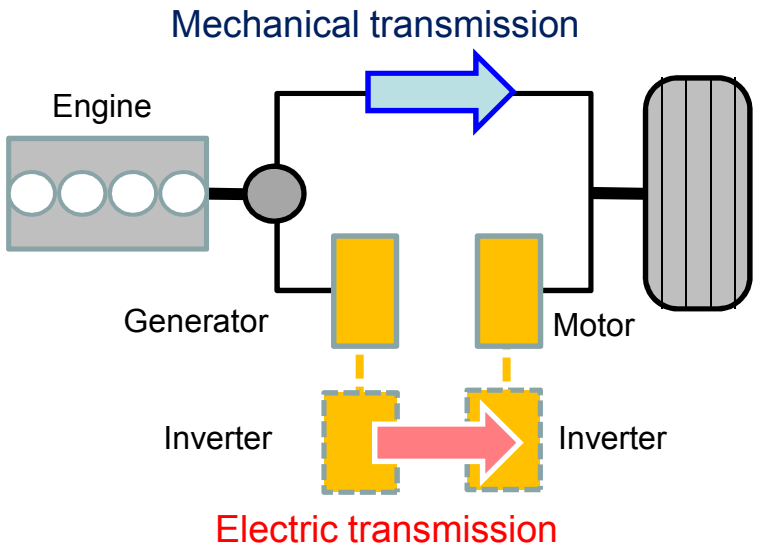
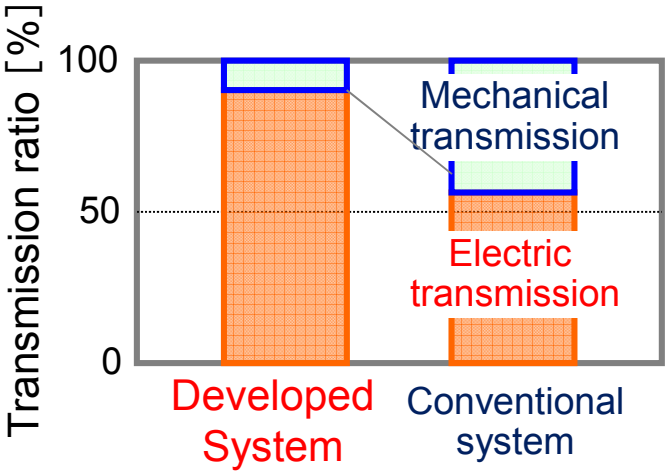
Conventional Hybrid Systems

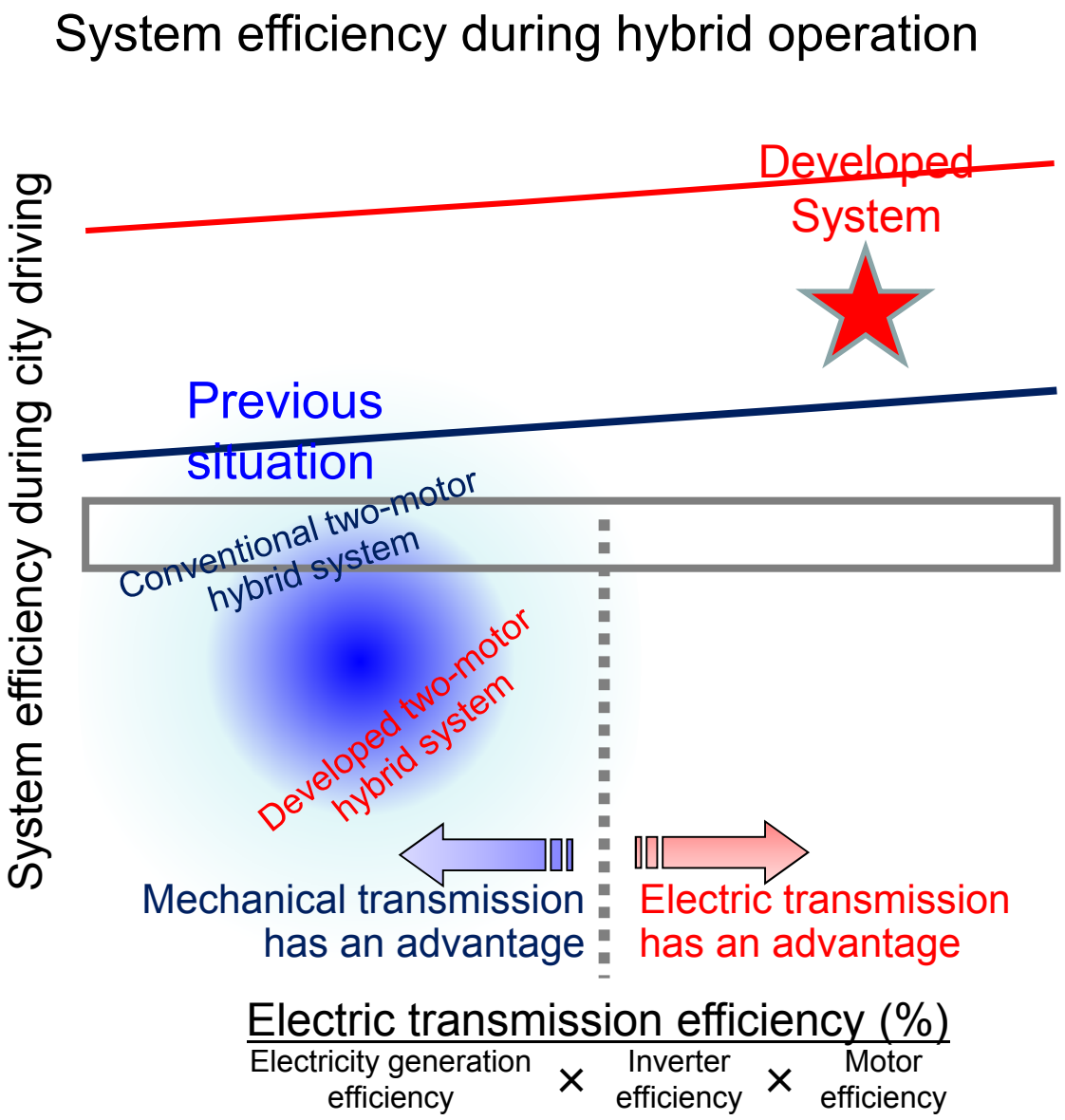
Electric Transmission
Mechanical transmission

Parallel Hybrid	Series/Parallel Hybrid	Series Hybrid
		
1MOTOR	2MOTORS	
Advantage: Smaller system size Light system weight Disadvantage: Using conventional transmission	Advantage: Engine operating points can be selected with smaller restriction related to vehicle speed Disadvantage: Complicated system configuration and control method	Advantage: Engine operating points can be selected without any restriction related to vehicle speed Disadvantage: Battery input/output loss Large battery size
100% Mechanical transmission	Electric/Mechanical transmission ratio variable	100% Electric transmission

Basic Concept of Efficiency Enhancement







Taking an advantage by enhancing electric efficiency

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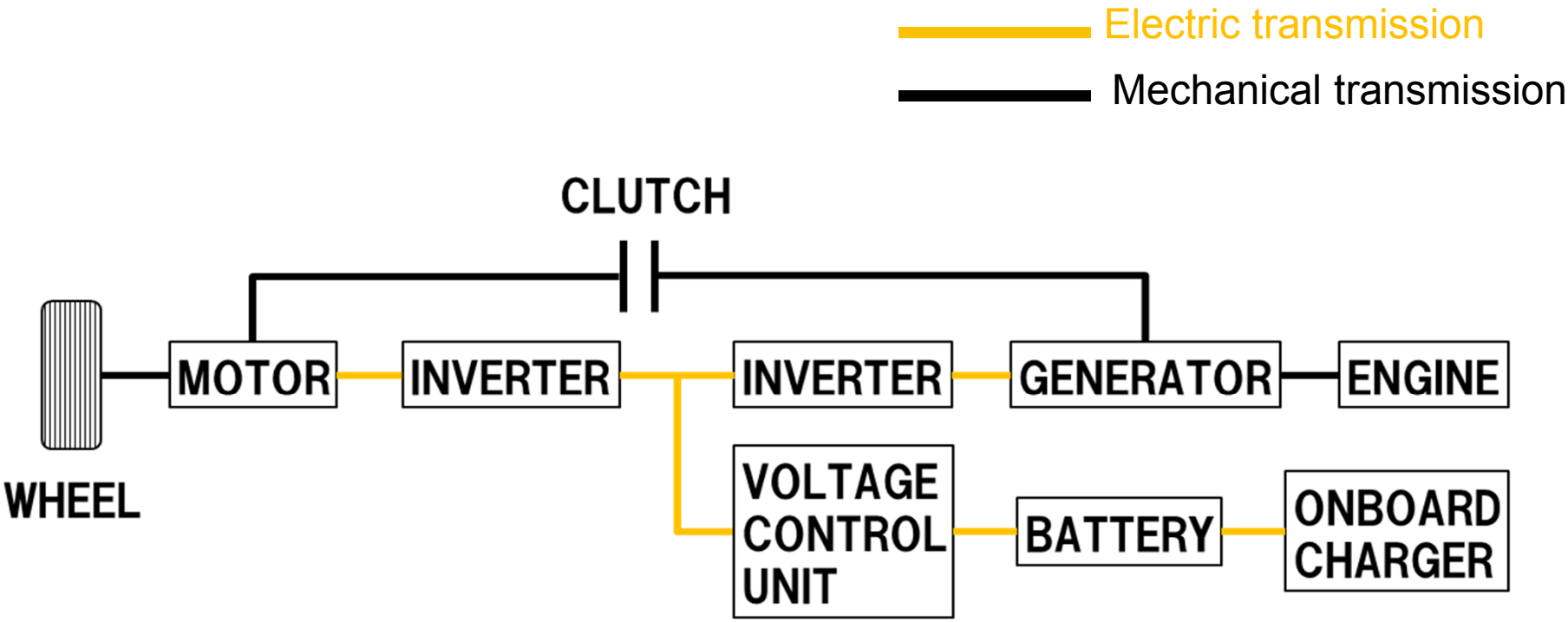
Block Diagram of Powertrain System

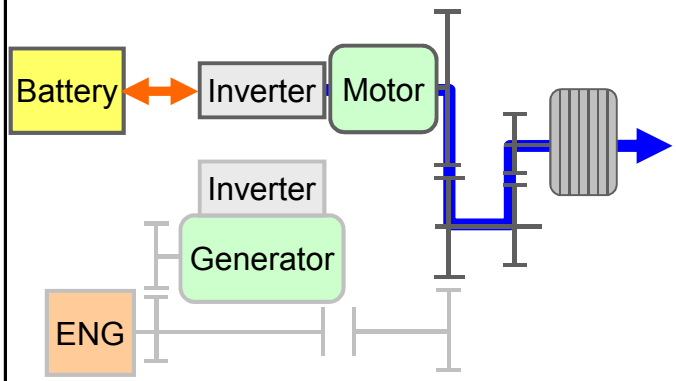
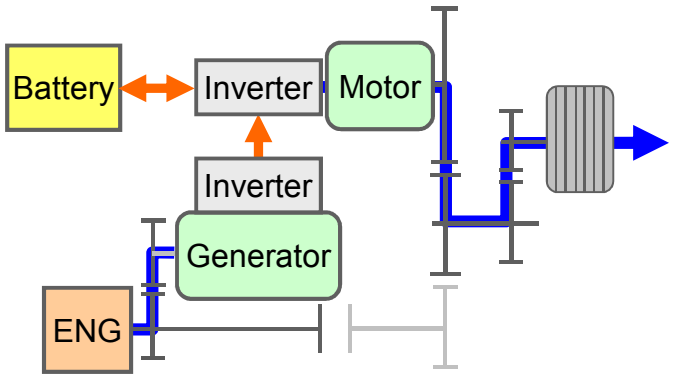
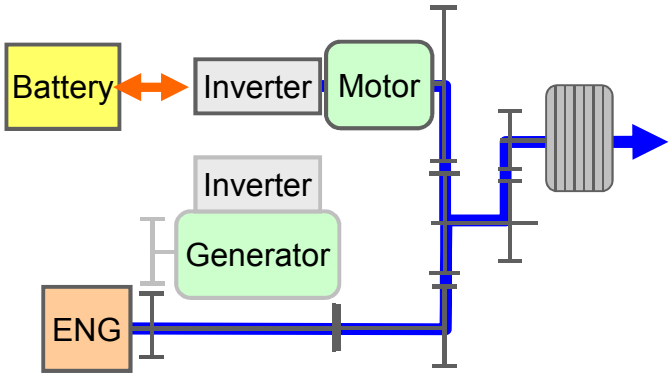


- Apply Series hybrid based system to enlarge electric transmission
- Battery acts as a power buffer to avoid charge-discharge loss
- Add a mechanical clutch to realize engine direct drive

Operation Modes

Electrical Transmission

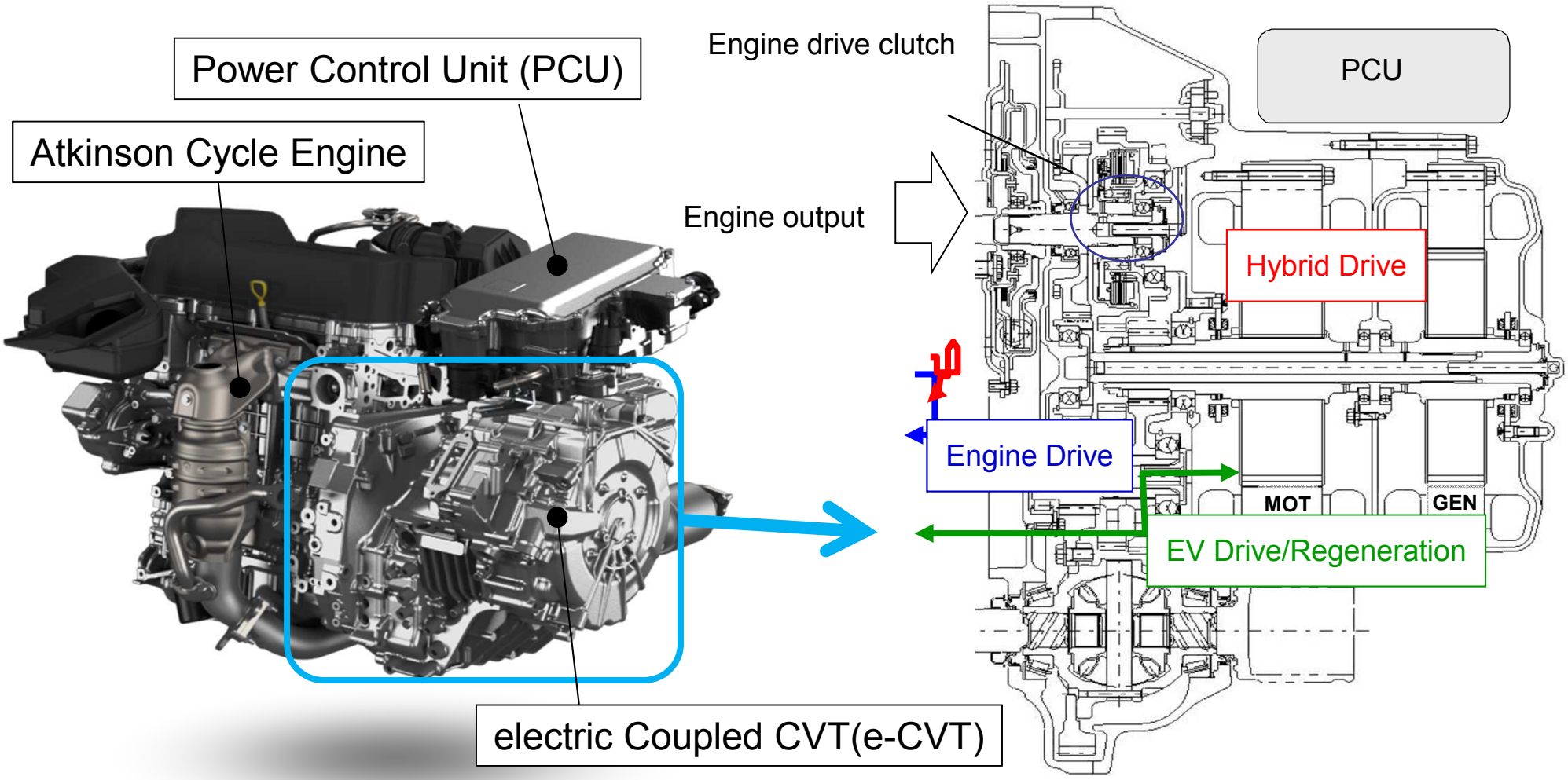
Mechanical Transmission

EV Drive	Hybrid Drive	Engine Drive
		
Use electric energy stored in the battery to drive the motor	Use electric energy generated by the engine to drive the motor, with assistance or charging of the battery	Use engine output to directly drive the wheels, with assistance or charging of the battery

Change three modes according to system efficiency

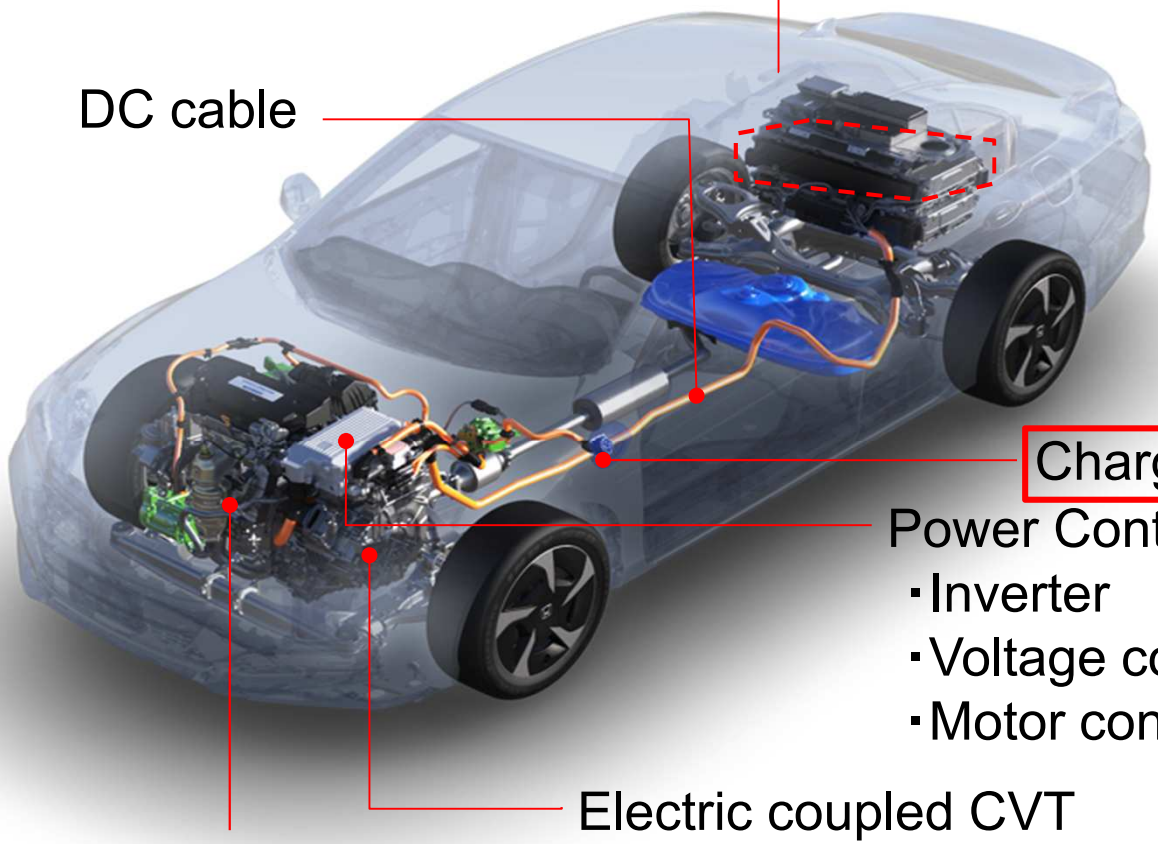
Power Train Overview

SPORT HYBRID i-MMD
intelligent Multi-Mode Drive



Switching engine and motor according to system efficiency

Overall System Configuration (Accord Plug-In)



Intelligent power unit
- DC/DC converter
- Battery control unit
- High capacity Li-ion battery
- Onboard charger

※PHEV exclusive

DC cable

Charge lid ※PHEV exclusive

Power Control Unit
- Inverter
- Voltage control unit
- Motor control unit

Atkinson cycle engine

Electric coupled CVT
- Clutch
- Motor / Generator

Equip the developed system with practical plug-in EV capability by installing a high capacity battery and an onboard charger.

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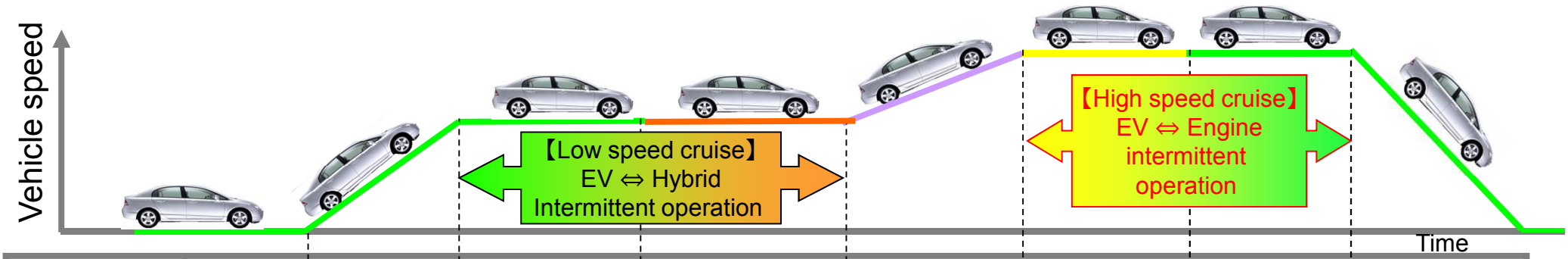
Basic Mode Transition

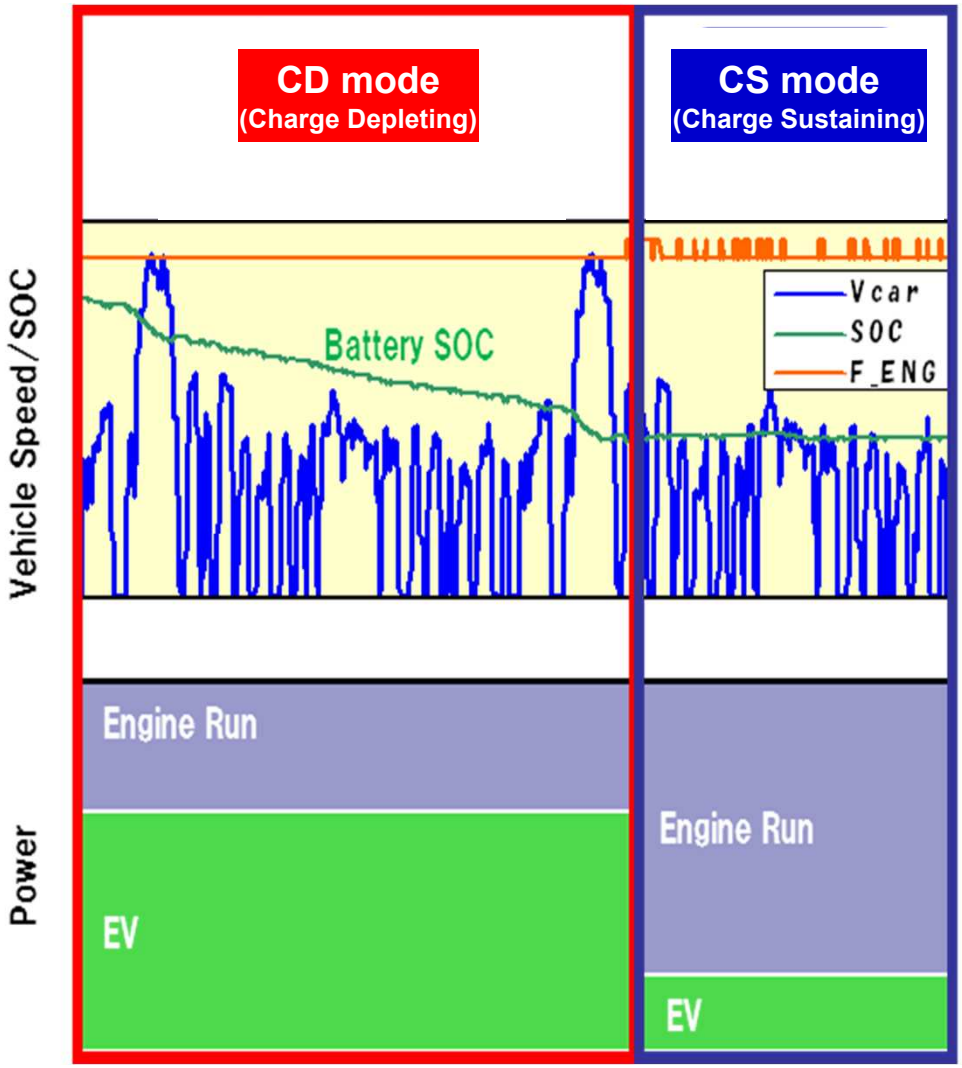


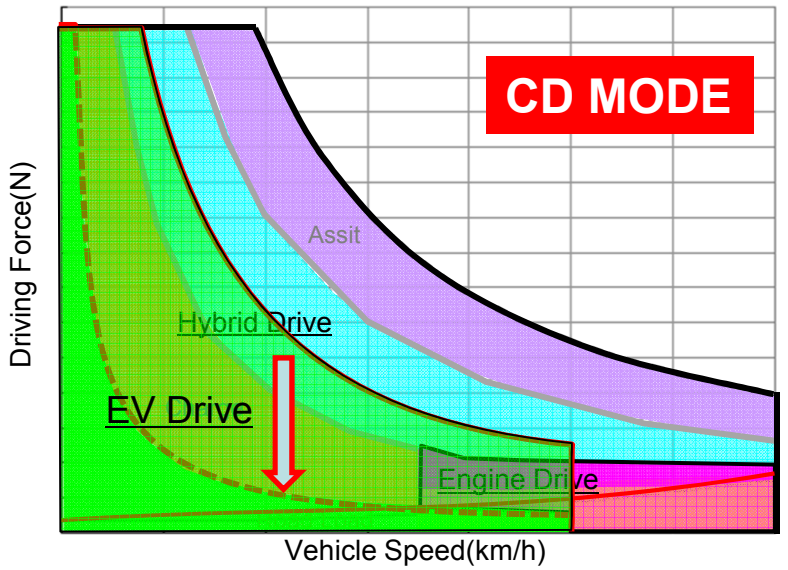
MOTOR	Stopped	Running				Generating	Running	Regenerating
GENERETER	Stopped			Generating		No torque	Stopped	
ENGINE	Stopped			Running			Stopped	
BATTERY	Discharging			Charging	Discharging	Charging	Discharging	Charging
BATTERY SOC								
Operation	Idle Stop	EV	EV	Hybrid (Charge)	Hybrid (Assist)	Engine (Charge)	EV	EV (Regeneration)

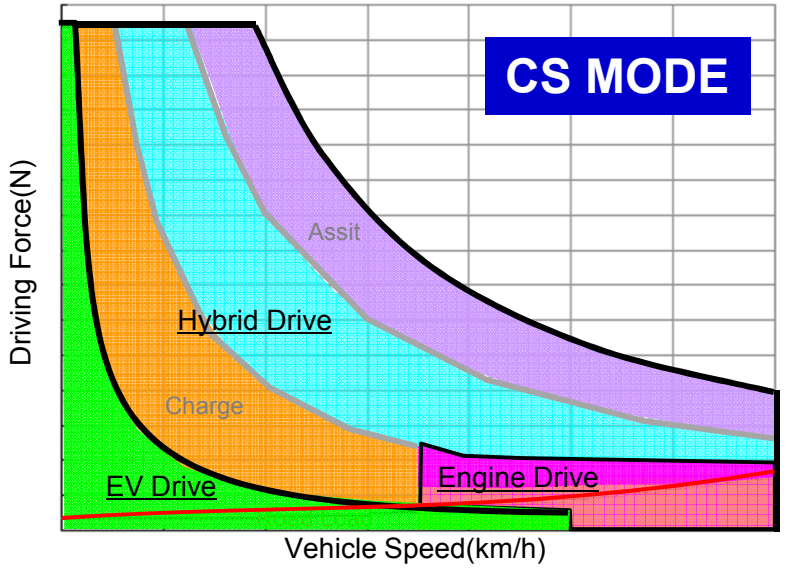
- Select suitable operation mode according to driving situation
- If the vehicle is cruising, intermittent operation is selected to enhance thermal efficiency of the engine

Comparison of Power Management Control

■ Mode transition between CD and CS mode







Adjust “EV Drive” area depending on battery SOC

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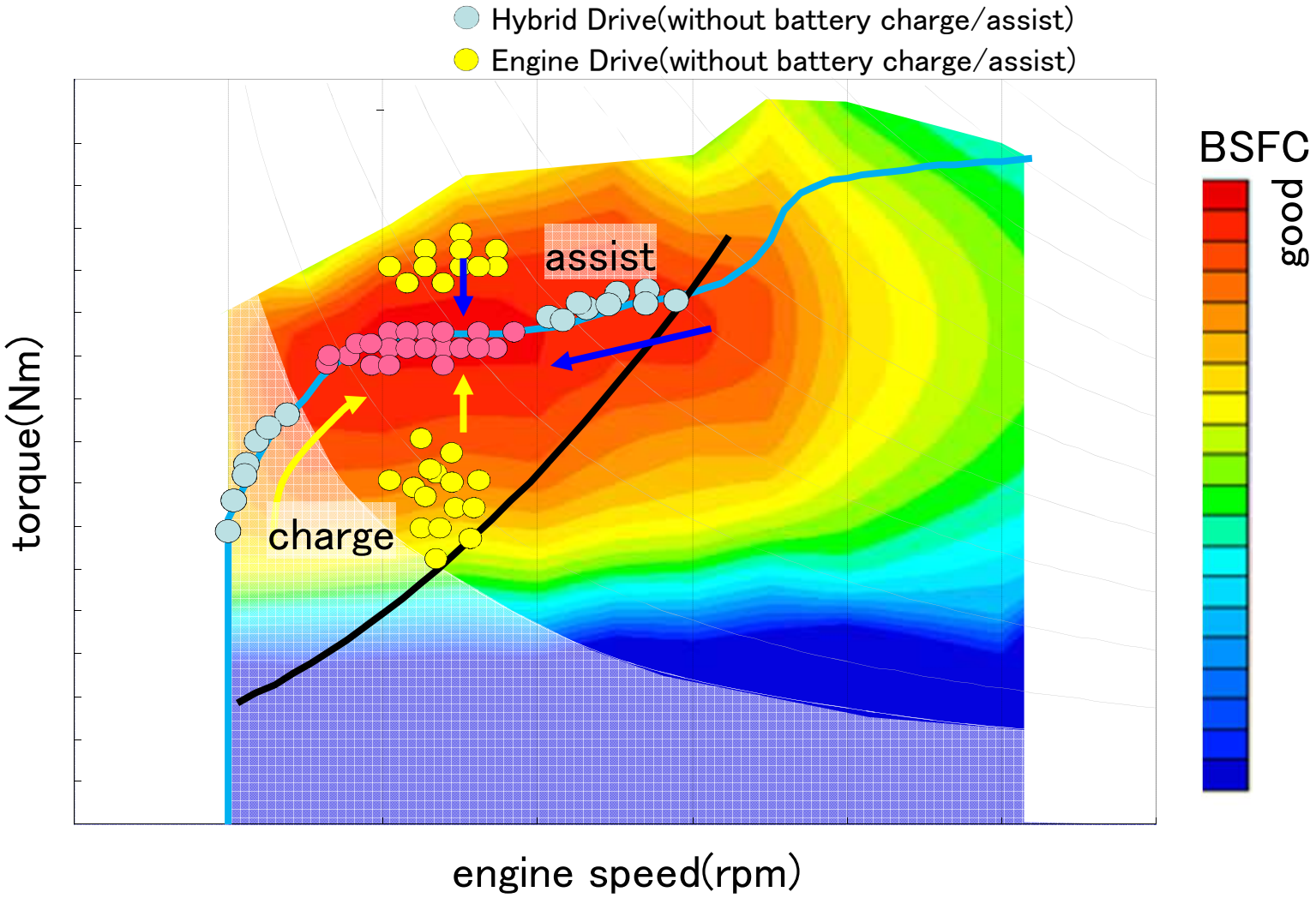
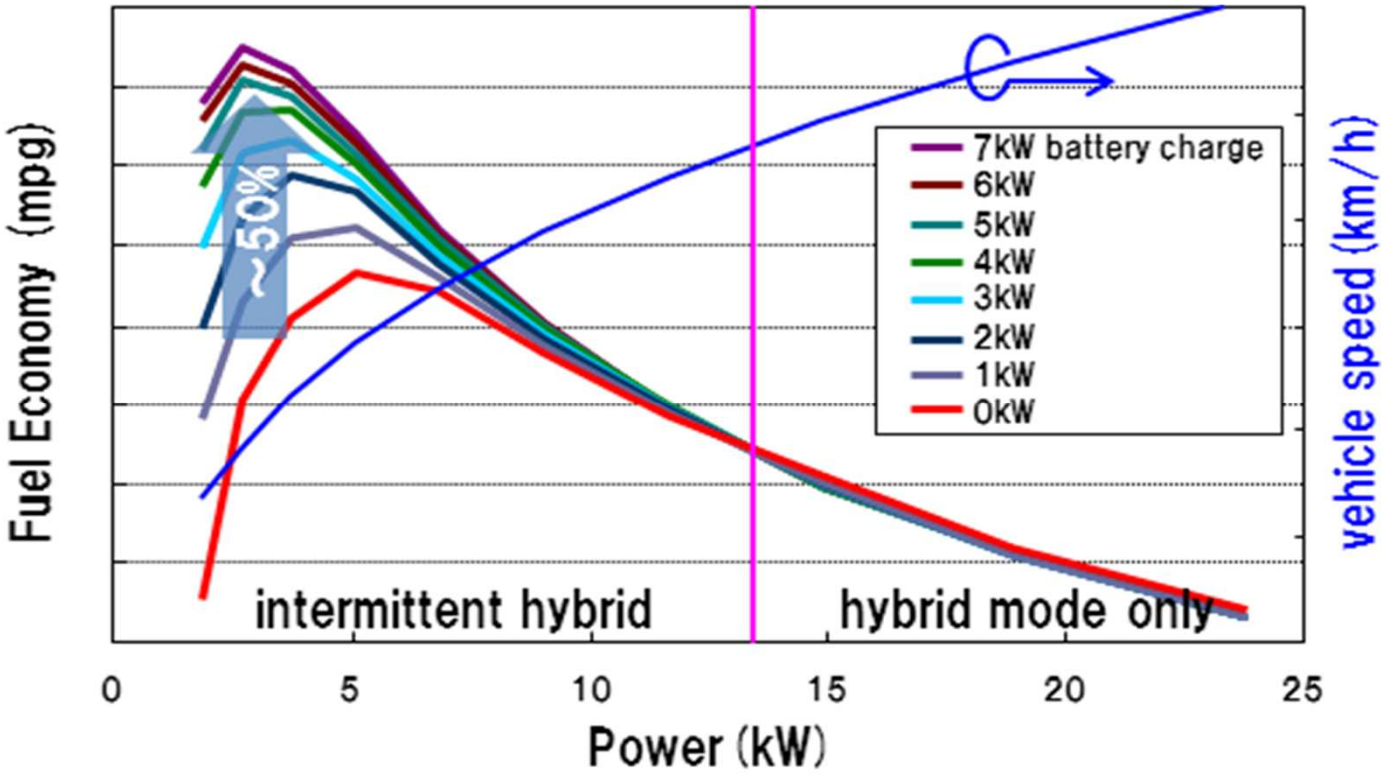
Engine Output Adjustment



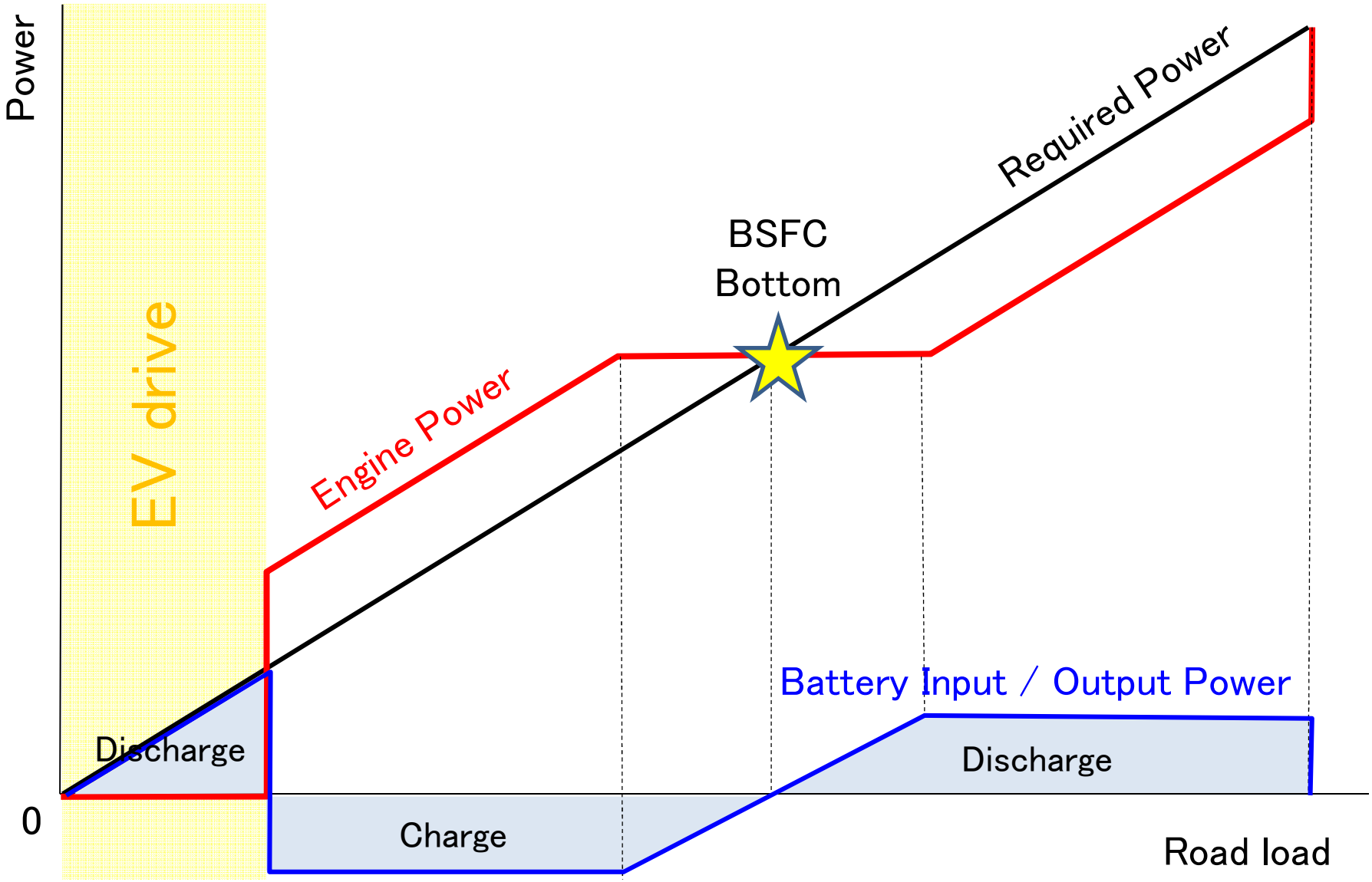
Moving engine operating point toward the most efficient area by adjusting engine load

Intermittent Operation

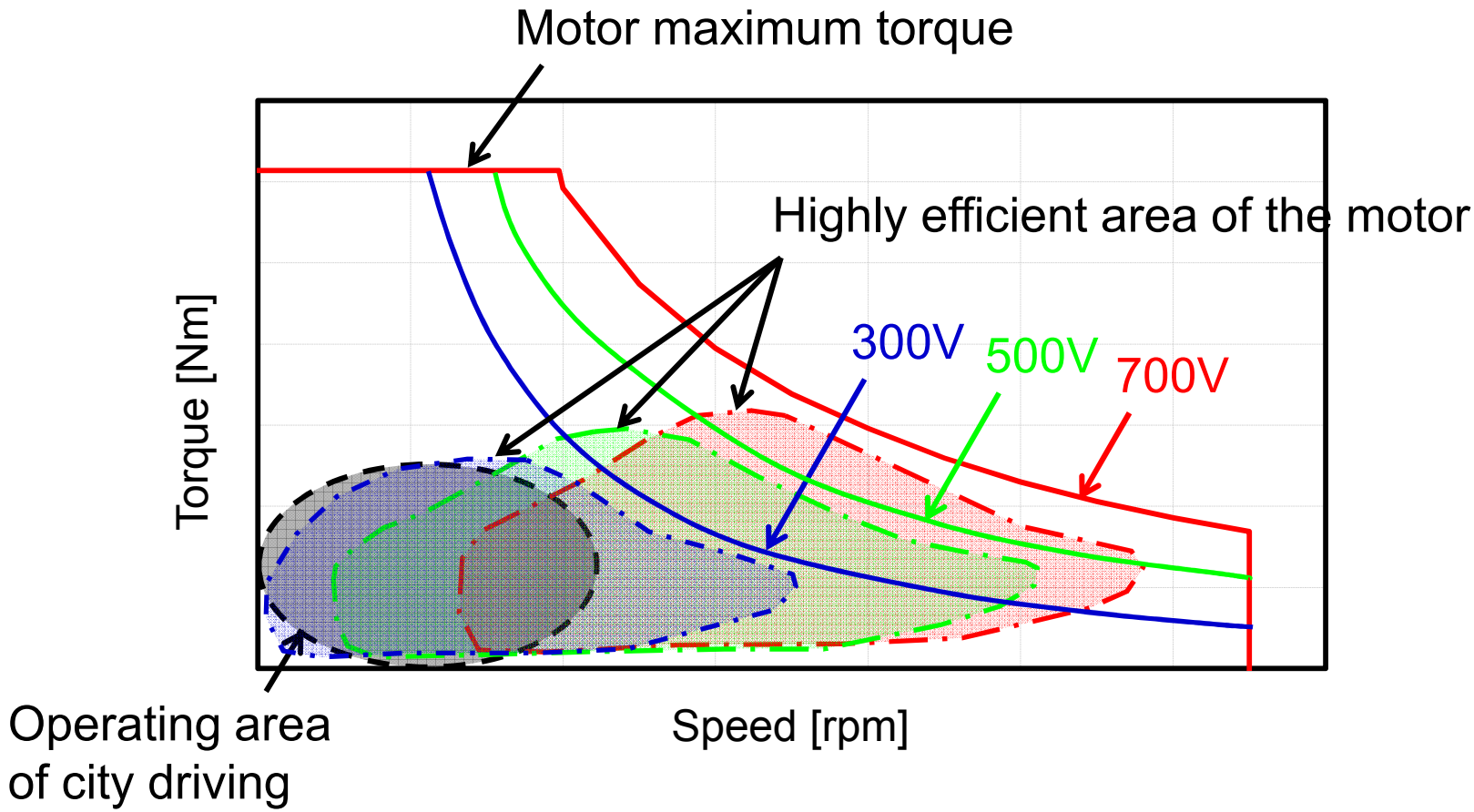


Intermittent operation is effective
if required power is lower then 15kW

Power Management



Voltage Amplification



- Move highly efficient area depending on required output
- Enhance the motor power without upsizing

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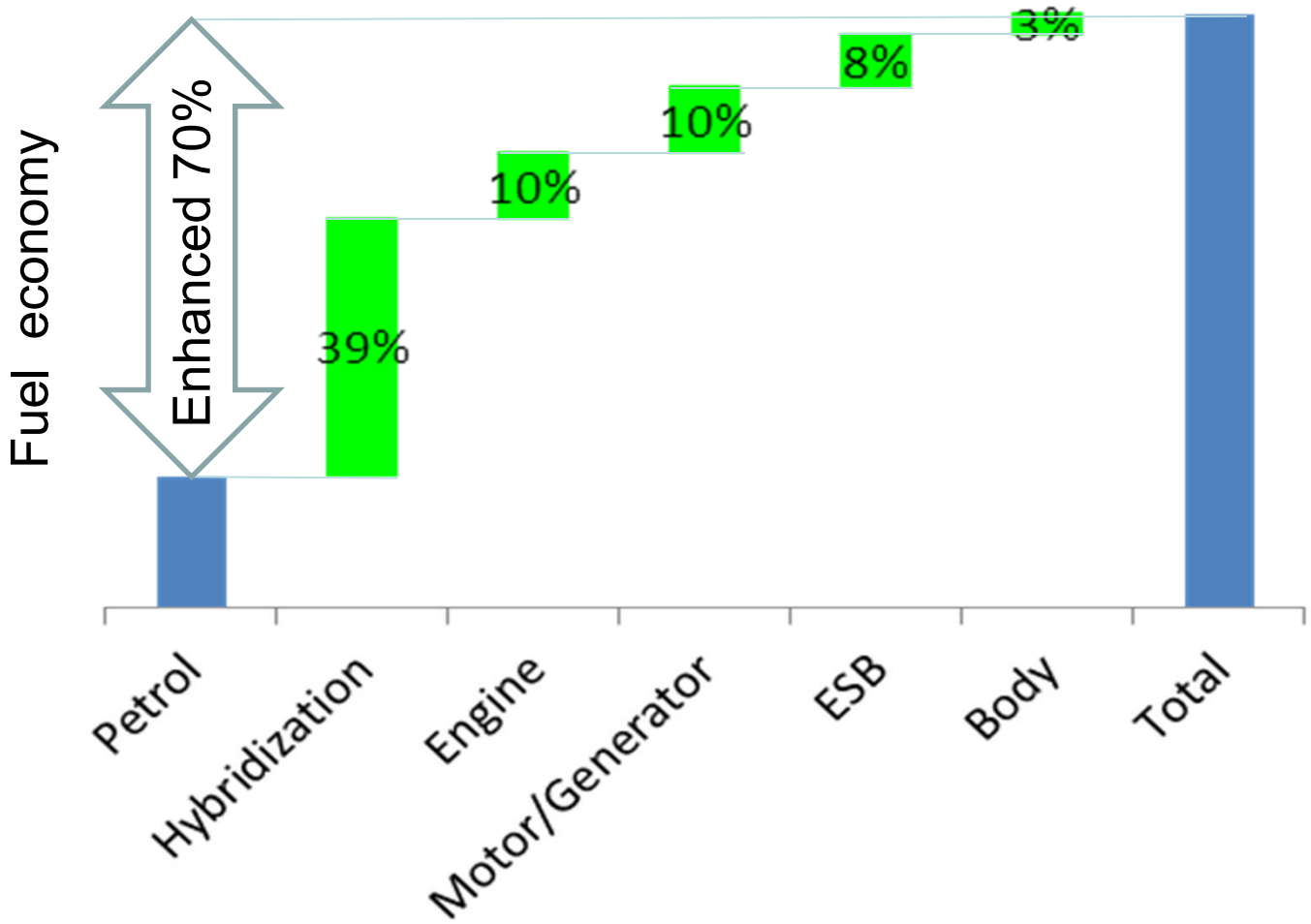
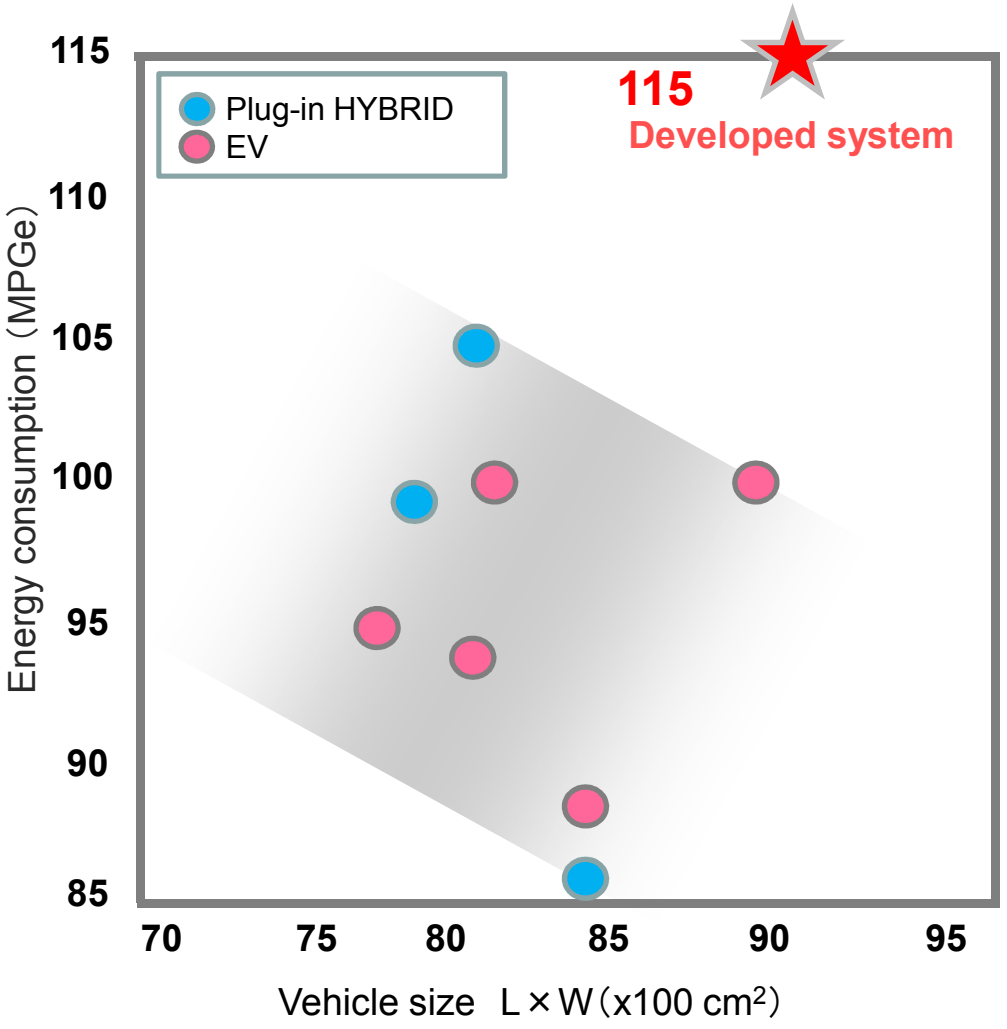
Contributions to Fuel Economy Enhancement



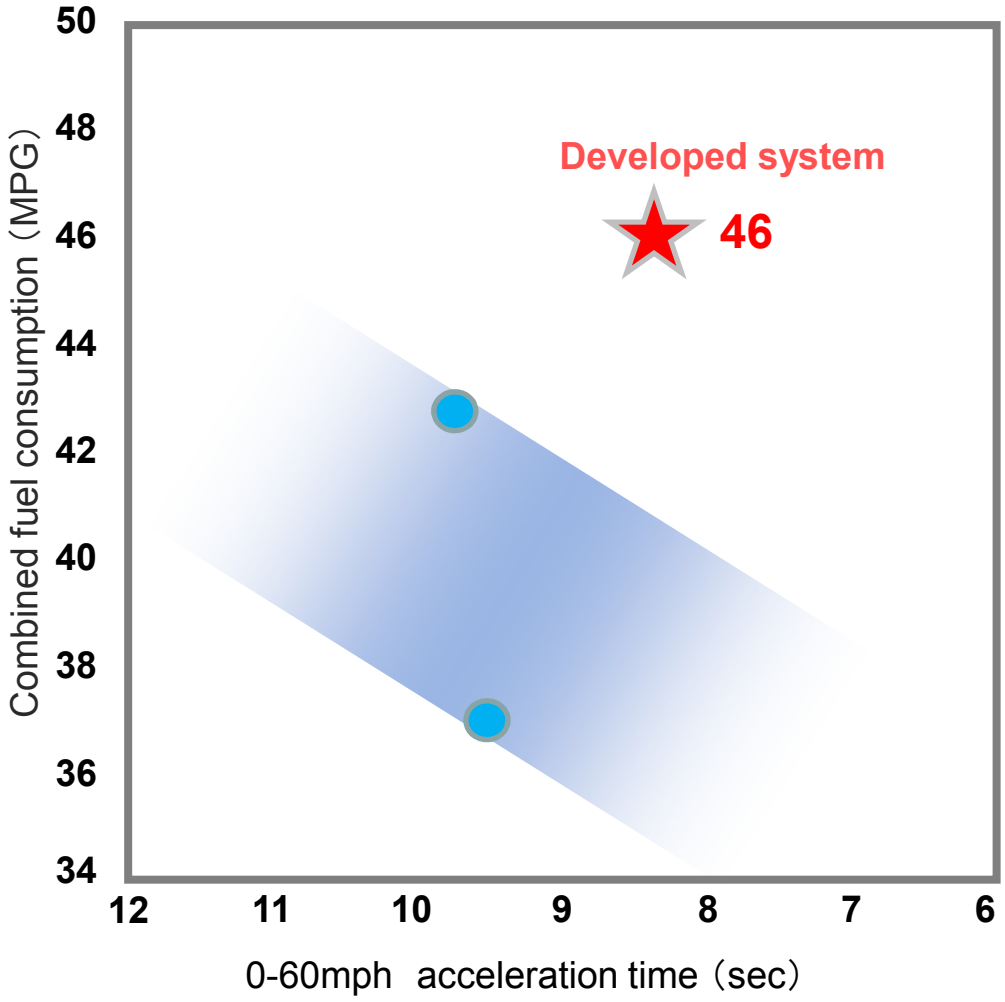
Total fuel economy is enhanced approximately 70%

Achieved Performance (2014 Accord Plug-In)

Vehicle size vs MPGe



Acceleration time vs Fuel consumption



Achieve both high levels of fuel economy and driving performance

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Conclusion

- Reduction of CO_2 emission is an urgent issue for the automobile industry.
- A new two-motor hybrid system named "i-MMD" (intelligent Multi-Mode Drive) was developed to maximize powertrain efficiency.
- As a result of installation on Accord Plug-In, following fuel consumption values are achieved.

  EV range: 13 mile

  Fuel economy: 115 MPGe (Charge depleting)

  46 MPG (Charge sustaining)