

# Hybrid Power Determination

Comment from JAPAN

Hybrid system power  
 $TP1 = R1 + R2$

7.Oct.2019

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# Background

EVE-31-05e  
Power determination  
Discussion of TP1 and TP2 and various hybrid configurations  
Discussed at EVE teleconference, May 10, 2019

Concept from EVE-31-05e  
**Hybrid system power(TP1) = R1+R2**

**R1**  
Conventional ICE

**R2**  
Additional power  
for hybridization

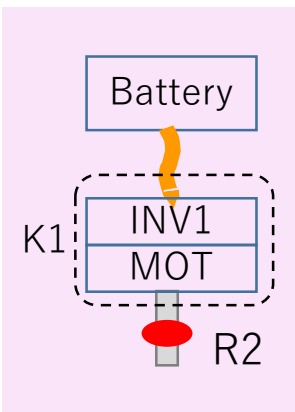
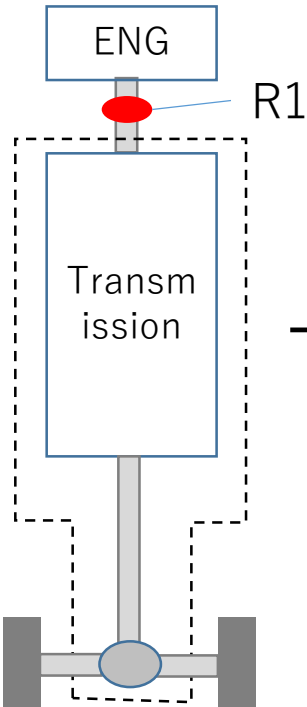


Fig.2 R2

Fig.1 R1

## Pending issues for TP1

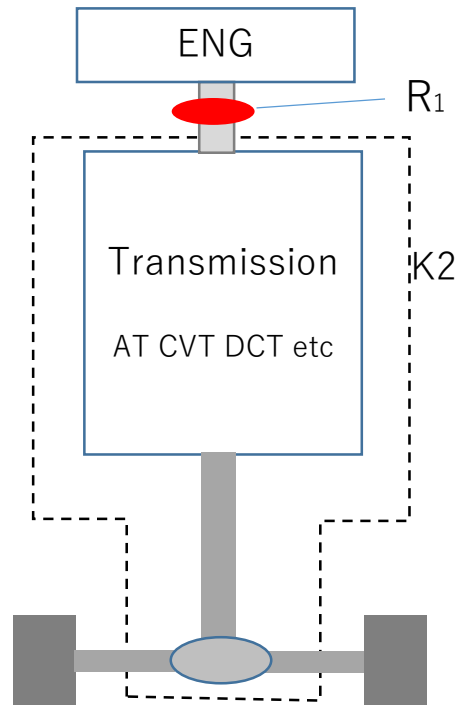
- Double counting of engine output (R1) in series hybrid.
- In case of multiple inverters in a series hybrid, necessity of measurement power for each inverter individually.
- Definition of R1 and R2 in power split hybrid.

**Japan proposes solutions.**

# Elements of system power determination

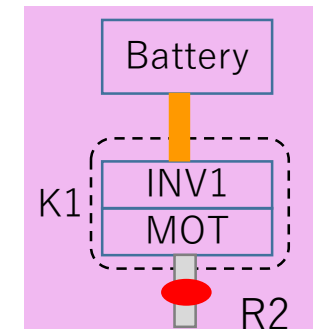
$$\text{Hybrid system power} = R1 + R2$$

Conventional ICE power rating  
**R1**



**Fig.1**

Additional power for hybridization  
**R2**

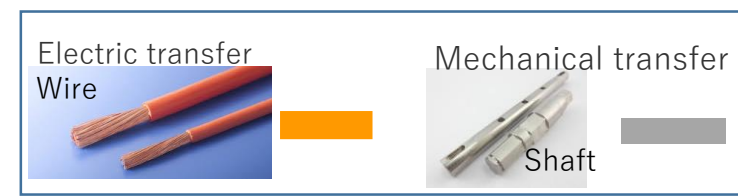


**Fig.2**

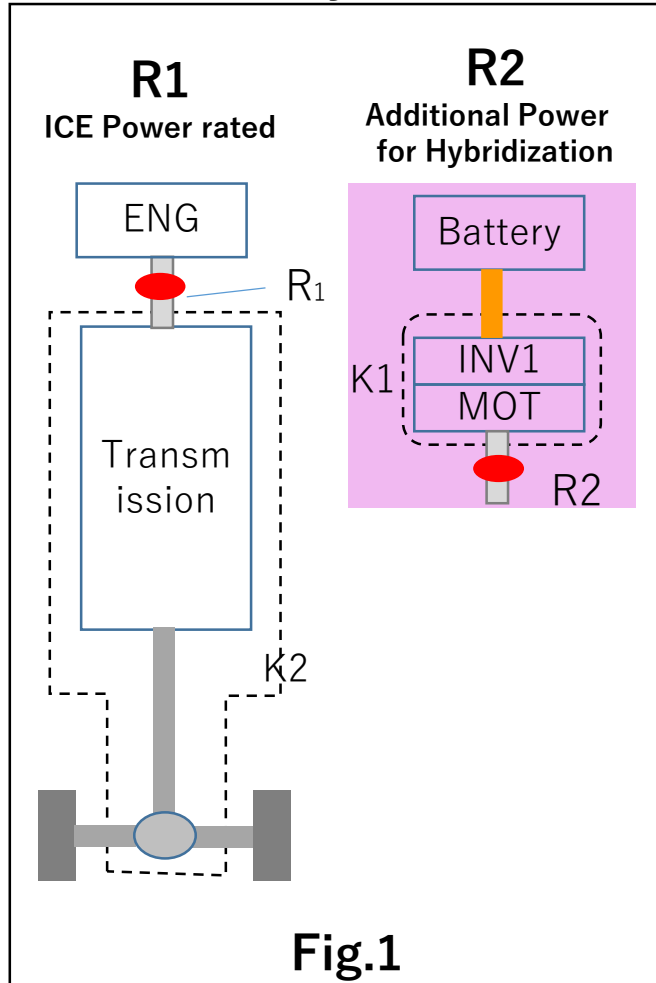
The system power rating should be comparable to the traditional engine-based power rating of conventional vehicles.

# Basic concept

# Application examples



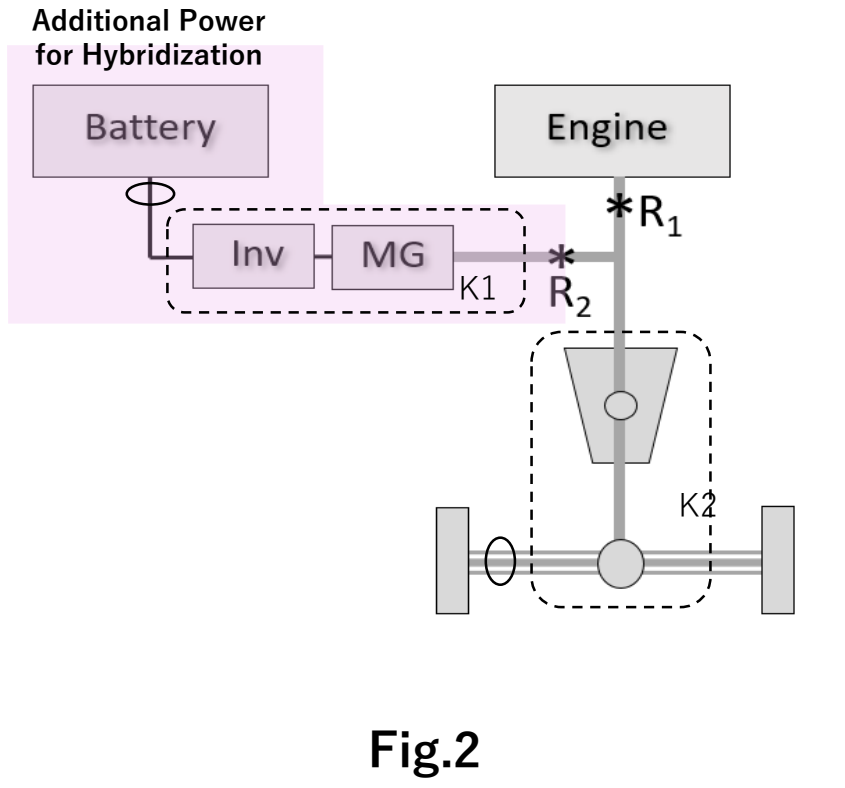
## Elements of system power



## Hybrid (P1 P2)

$$TP1 = R_1 + R_2$$

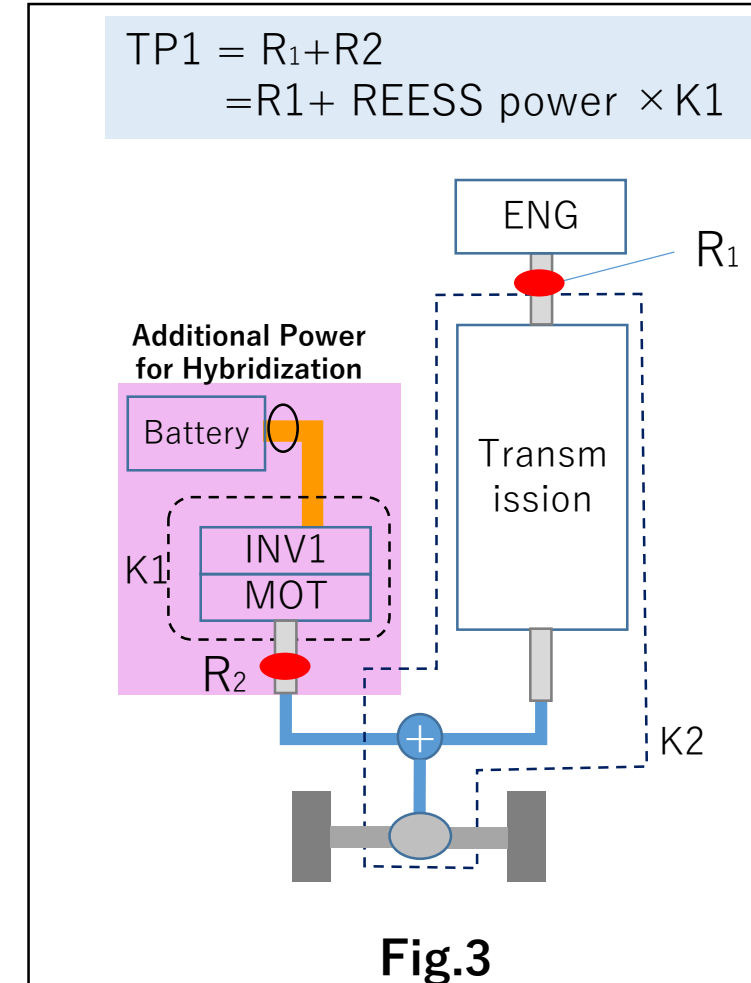
$$= R_1 + \text{REESS power} \times K_1$$



## Hybrid (P3)

$$TP1 = R_1 + R_2$$

$$= R_1 + \text{REESS power} \times K_1$$



**R1+R2 concept can be applied to every kind of hybrids.**

# Definition of R1 and R2

Conventional ICE power rating

R1

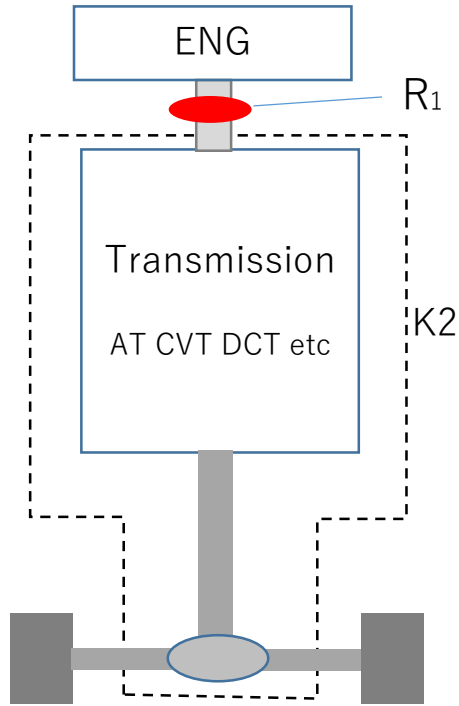


Fig.1

**R1 = ICE originated power**

Additional power for hybridization

R2

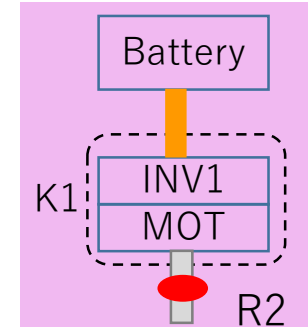


Fig.2

**R2 = Battery originated power**

R1 should be comparable to the traditional engine-based power rating of conventional vehicles.

Note; R1 does Not include any losses downstream of engine

**R1 and R2 can be defined by the origin of energy.**

# Case1 Series Hybrid

Conventional ICE power rating  
 $R_1$

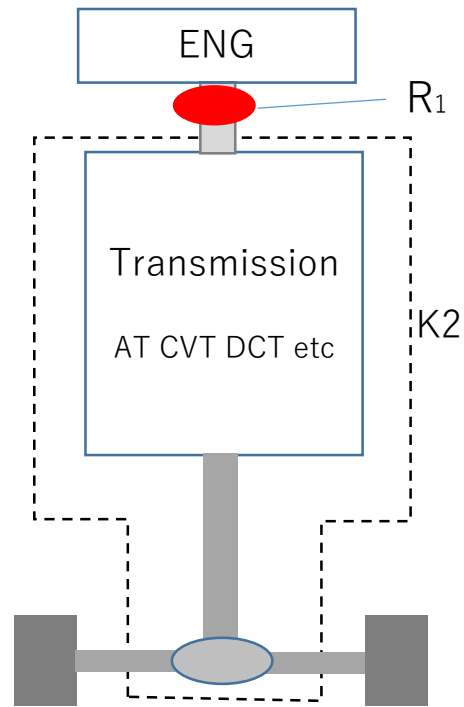


Fig.1

$R_1$  = ICE originated power

Elements of series hybrid

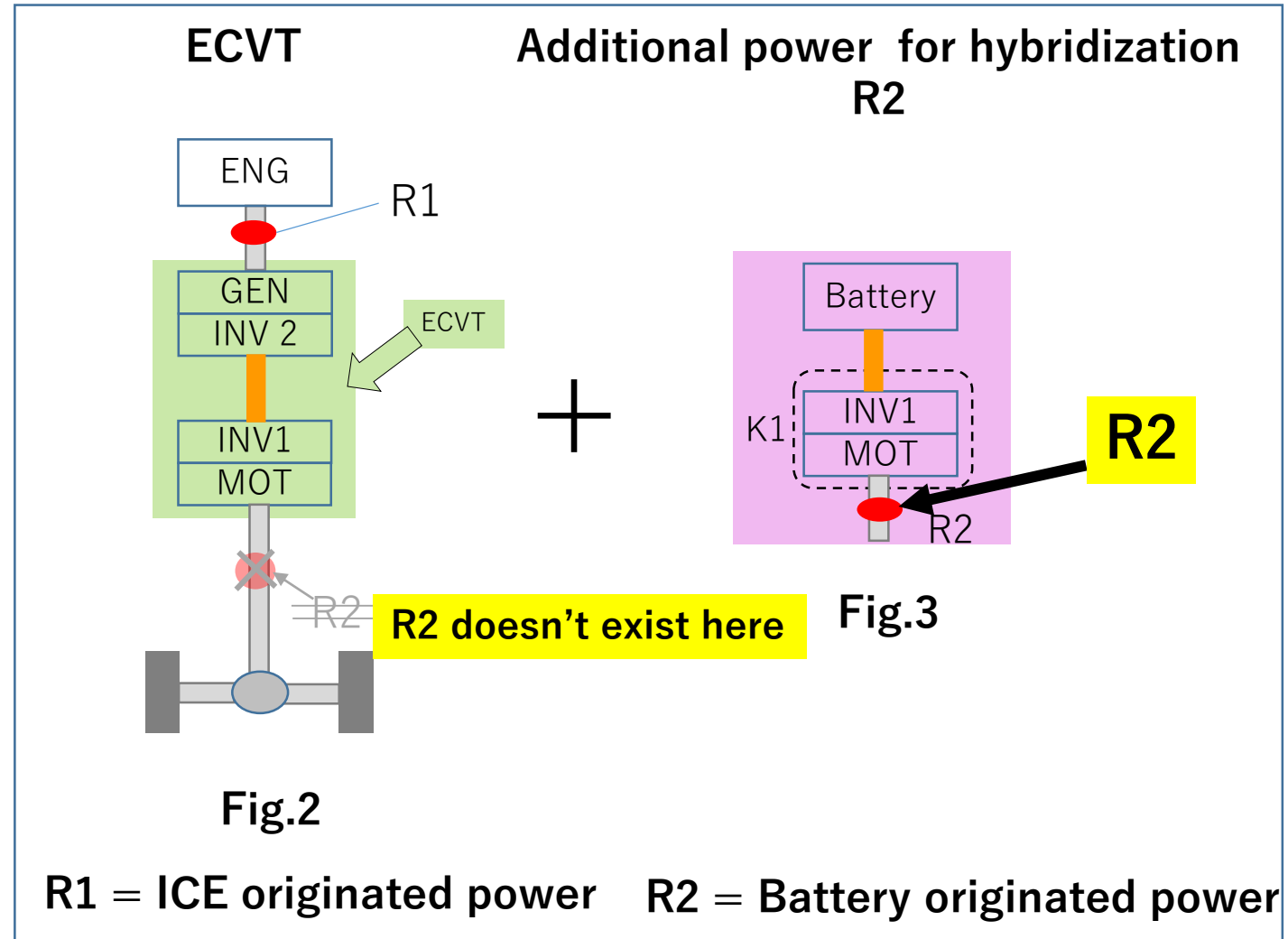
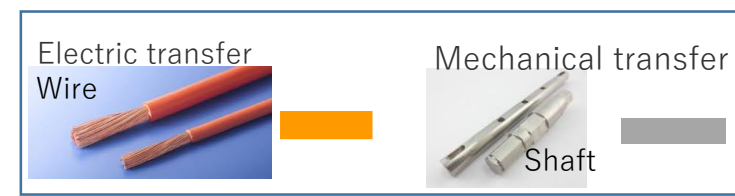


Fig.2

$R_1$  = ICE originated power  $R_2$  = Battery originated power

Series hybrid is summation of  $R_1$  and  $R_2$ .

# Case1 Series hybrid



## Series-Hybrid

$$TP1 = R1 + REESS \text{ power} \times K1$$

$$= R1 + R2$$

From this formula

$$R2 = REESS \text{ power} \times K1$$

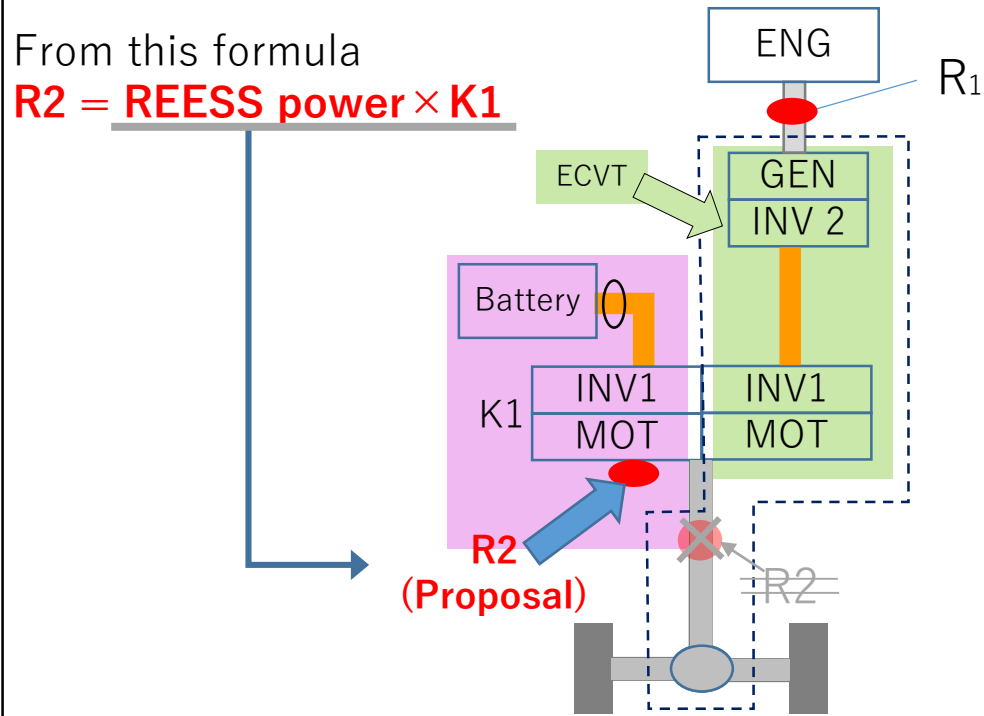


Fig.1 Series Hybrid

## Hybrid (P3)

$$TP1 = R1 + R2$$

$$= R1 + REESS \text{ power} \times K1$$

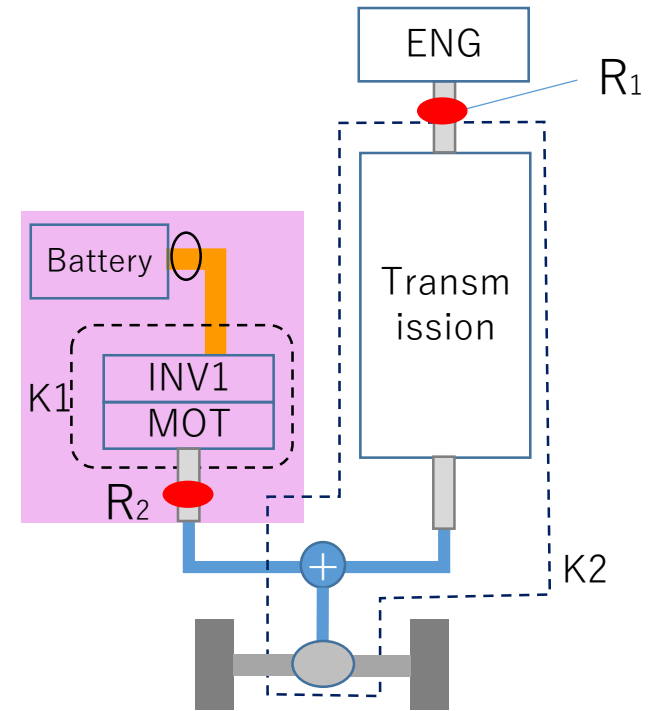
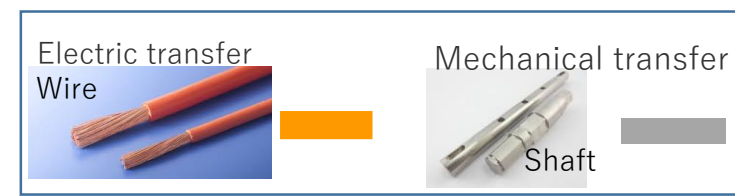


Fig.2

R1+R2 concept can be applied to series hybrid also.



# Case1 Series Hybrid



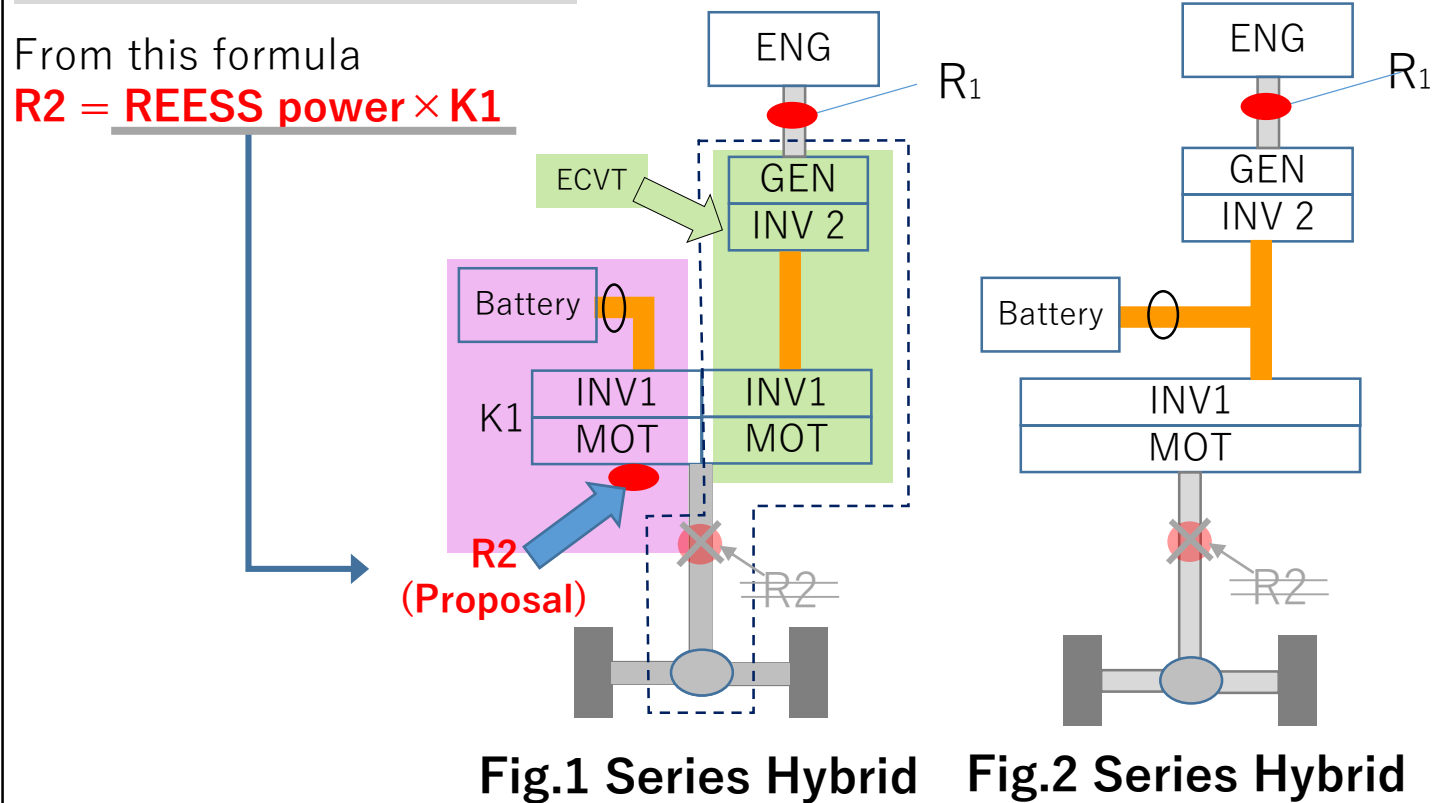
## Series hybrid

$$TP1 = R1 + REESS\ power \times K1$$

$$= R1 + R2$$

From this formula

$$R2 = REESS\ power \times K1$$



## Issues and solutions

Fig1 is same meaning of Fig2.

R1 is ICE originated power and R2 is REESS originated power. Double-counting issue does not occur even if summing up R1 and R2. (Fig1)

R2 is defined as the battery originated power, it is sufficient to measure the battery power.

GEN/INV2 is downstream of R1. Measurement of GEN/INV2 power is not necessary for TP1. And losses of GEN/INV2 does not include for TP1.(Fig1)

# Case1 Series Hybrid TP1 give a higher result than TP2 ?

Discussion of EVE31

For series or mixed (power split) hybrids, **TP1 will always give a higher result** than TP2 because TP1 **does not account for electrical conversion losses** in the series portion.

Losses in the electrical conversion path (G + Inv2) would not be accounted for.

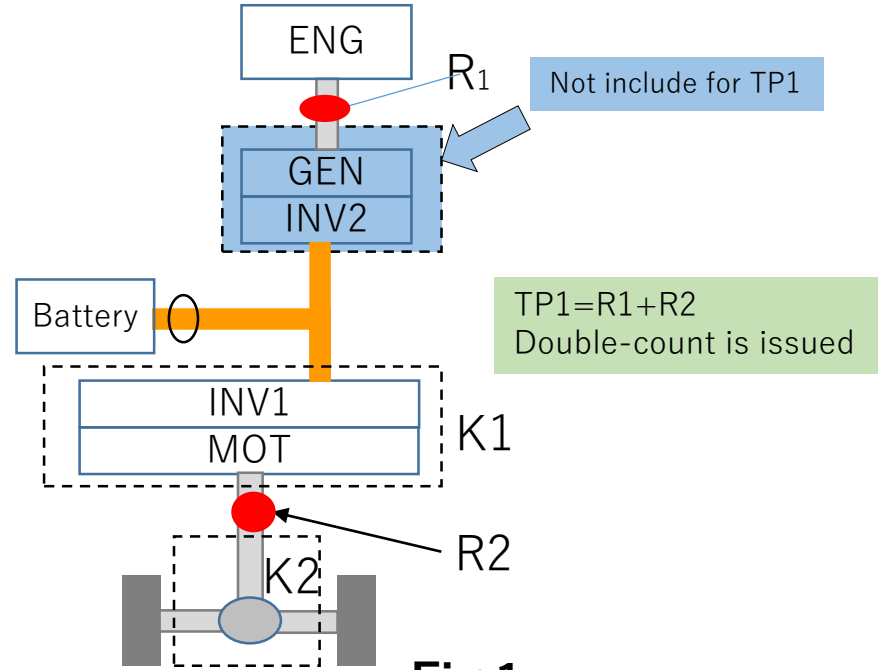


Fig.1

**TP1 > TP2 is occurred**

$$TP1 = R1 + R2$$

$$TP2 = \text{Drive shaft power} / K2$$

Proposal from JAPAN

**R2 is part of motor output, which REESS originated power only.**  
**Double-count of engine power does not occur, because R2 does not include engine originated power.**

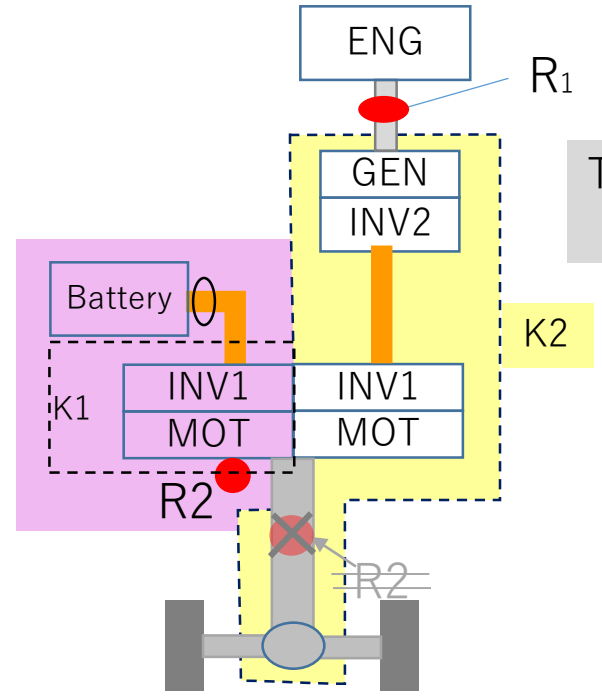
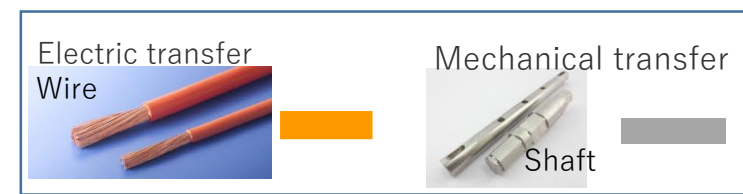


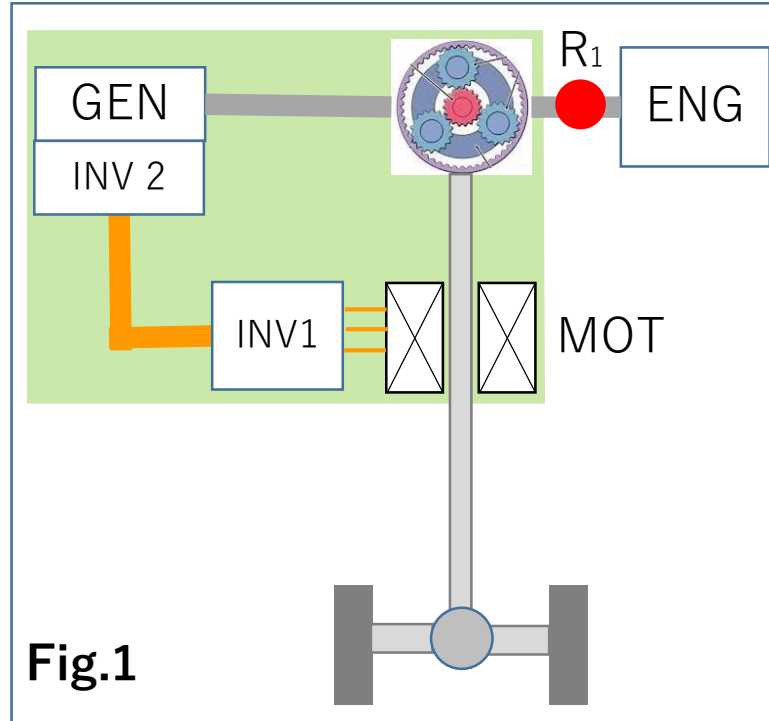
Fig.2

**TP1 does not show a higher value than TP2.**

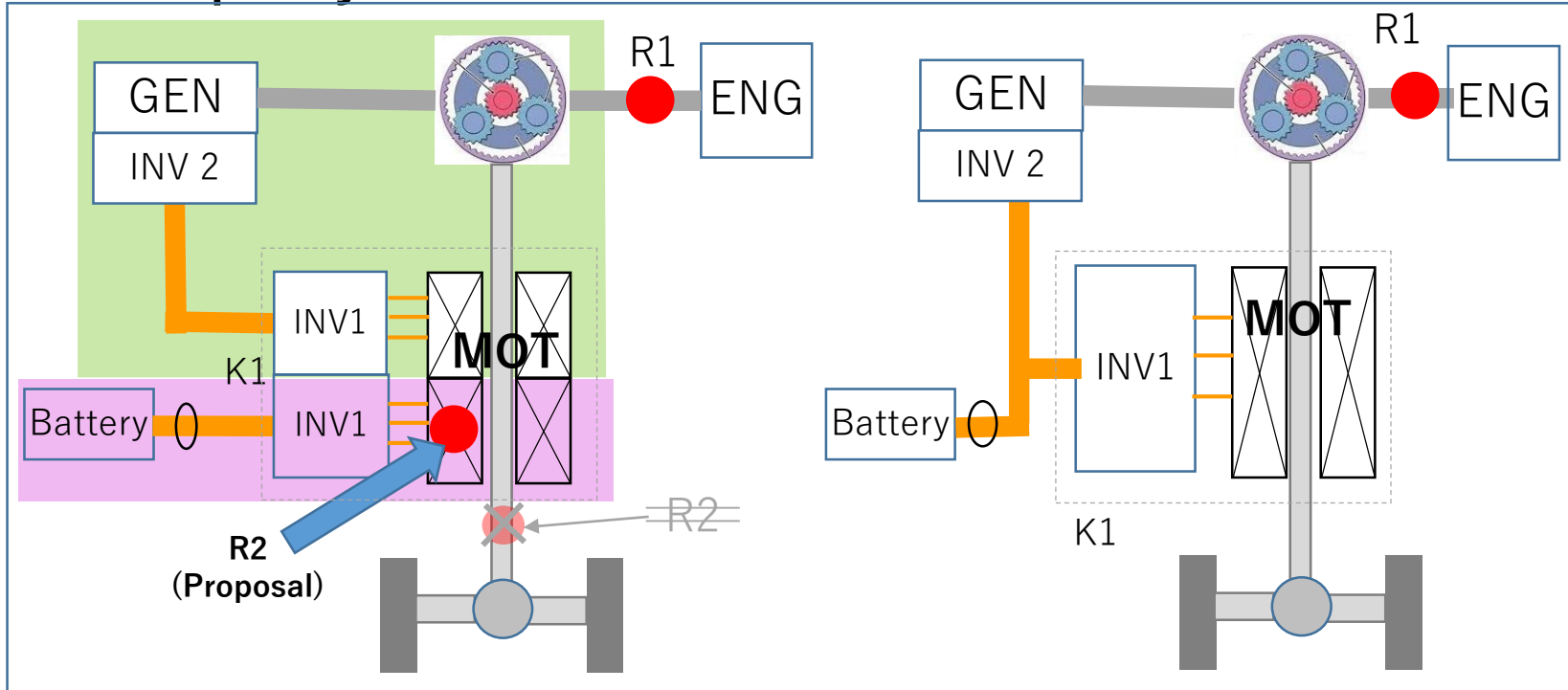
# Case2 Power split Hybrid (THS)



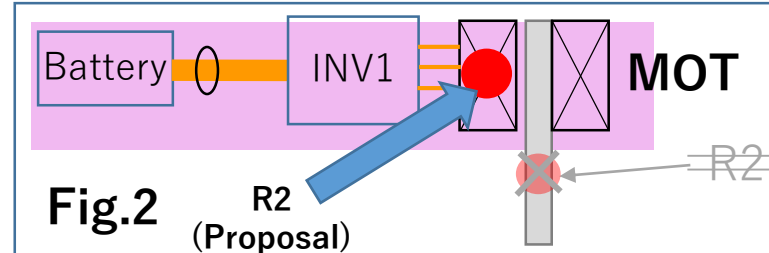
ECVT



Power split hybrid



Additional power for hybridization



$$TP1 = R1 + (\text{REESS power} \times K1)$$

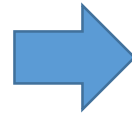
$$TP1 = R1 + R2$$

$$R2 = \text{REESS power} \times K1$$

TP1 for power split hybrid is as same as other hybrids

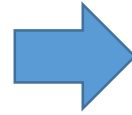
# Three issues and result

- Double counting of engine power R1 in series hybrid.



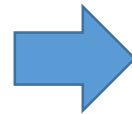
R1 is ICE originated power and R2 is REESS originated power.  
Double count does not occur even if R1 and R2 are summed.

- Multiple inverters in a series hybrid, necessity of measurement power for each inverter individually.



There is no need to measure GEN/INV2 power for TP1.  
Because GEN/INV2 is downstream of R1.

- Definition of R1 and R2 in power split hybrid.



Same as other hybrids.

# Conclusion

The hybrid is composed of ICE origin power and REESS origin additional power.

1. Every type of hybrids, TP1 can be expressed as  
 $TP1=R1 + R2$ .  
(Includes series hybrid and power split hybrid)

2. R2 is motor output from REESS originated power only ,  
should not include the engine originated power.

P3 Hybrid

$$TP1 = R1 + REESS \text{ power} \times K1$$

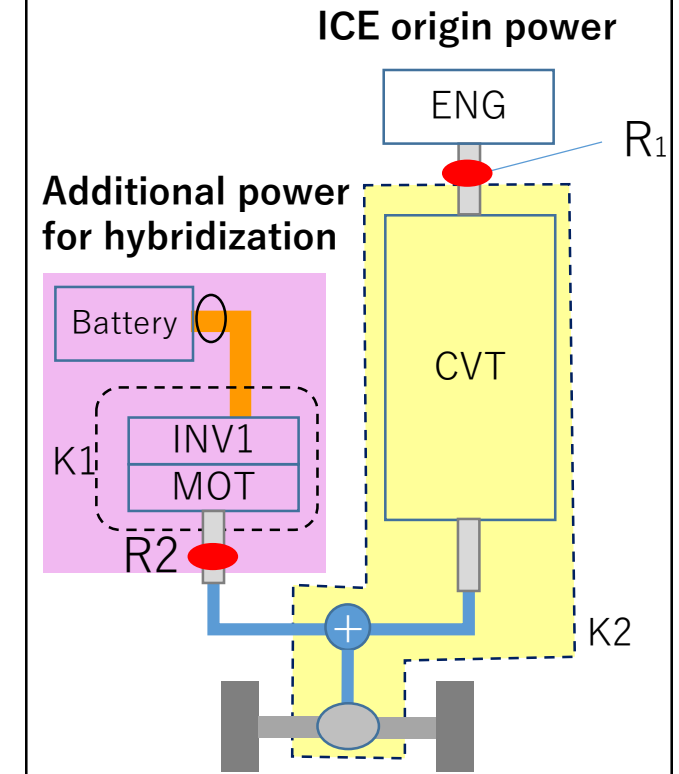


Fig.1

Thank you for your attention

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