Future society opened by direct dynamic wireless power transfer to EV

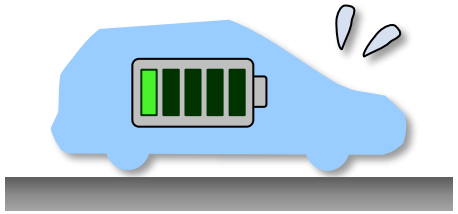
Hiroshi Fujimoto, O. Shimizu, S. Yamada, S. Nagai, T. Fujita

(The University of Tokyo, Graduate School of Frontier Science)

What is dynamic Wireless Power Transfer (DWPT)?

EV that can travel without worrying about remaining battery capacity

Problem: Existing EVs have shorter cruise range than ICVs

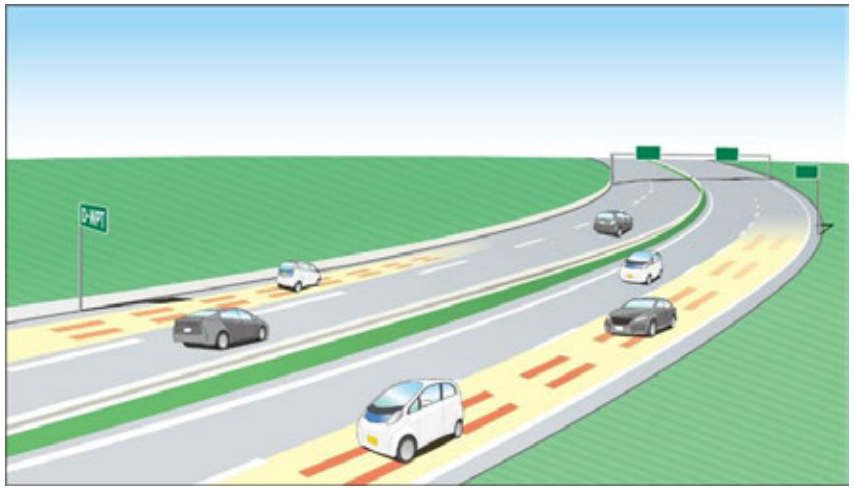


Solution 1:Load a lot of batteries

- ☐ EV gets heavier⇒ Increase of resistance, NOT efficient
- ☐ Cost increases

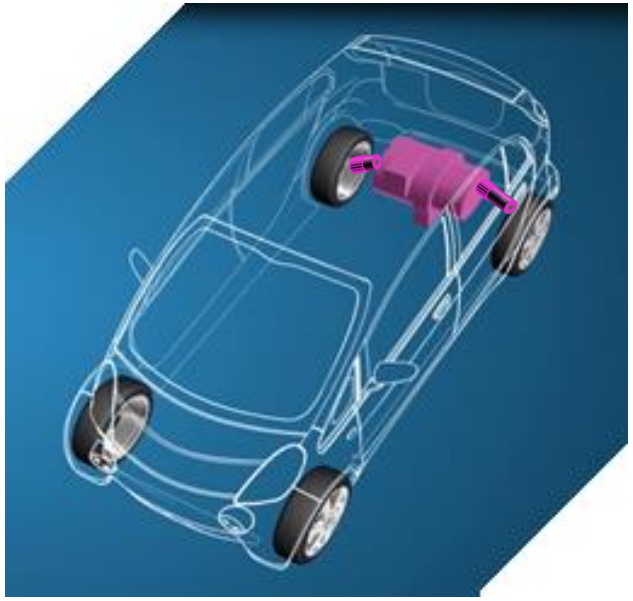
Solution 2: D-WPT

- ☐ EV receives electricity like a train
- ☐ Wireless power transfer from road coils

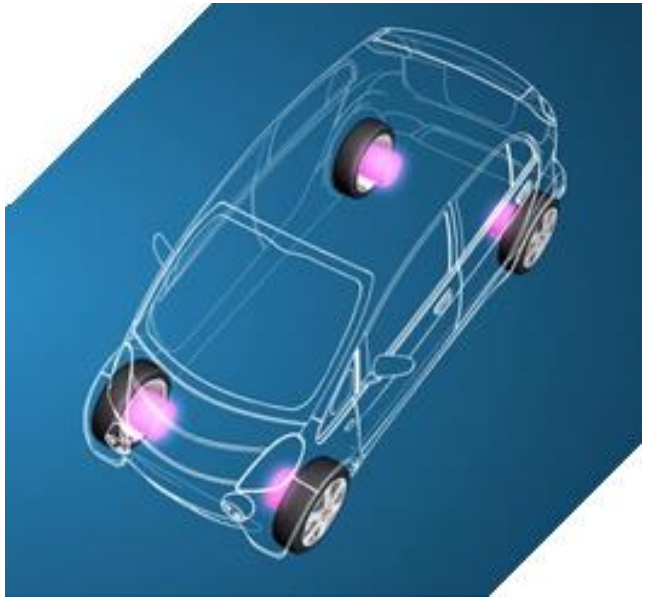


∞ cruising range

What is In-wheel Motor (IWM)?



Onboard Motor

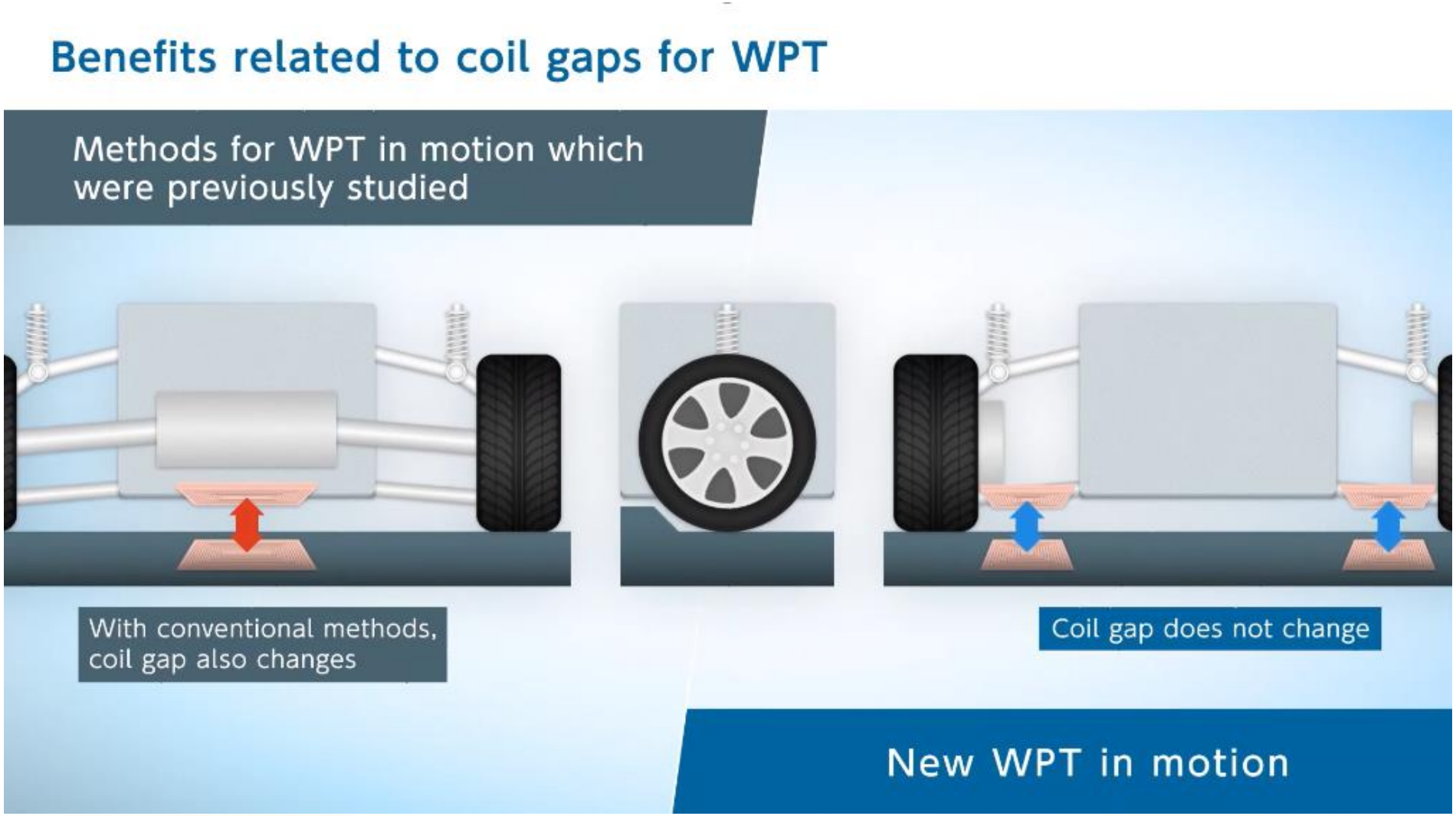


In-wheel Motor

- ✓ **Lighter and more environmentally friendly**
- ✓ **Safety improvement by independent driving force control of each wheel**
- ✓ **Wider interior space, comfortable**

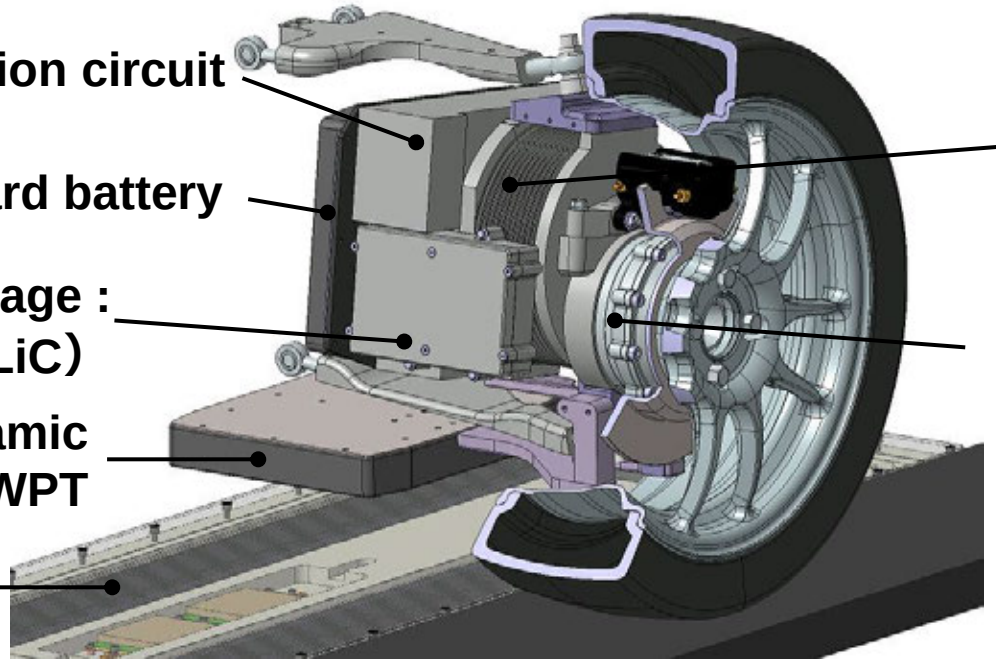
DWPT + IWM = Ultimate Driving System

Advantage of Wireless In-wheel Motor



High performance by layout of the receiver coil

System configuration of WIWM-2



All drive system is in unsprang area

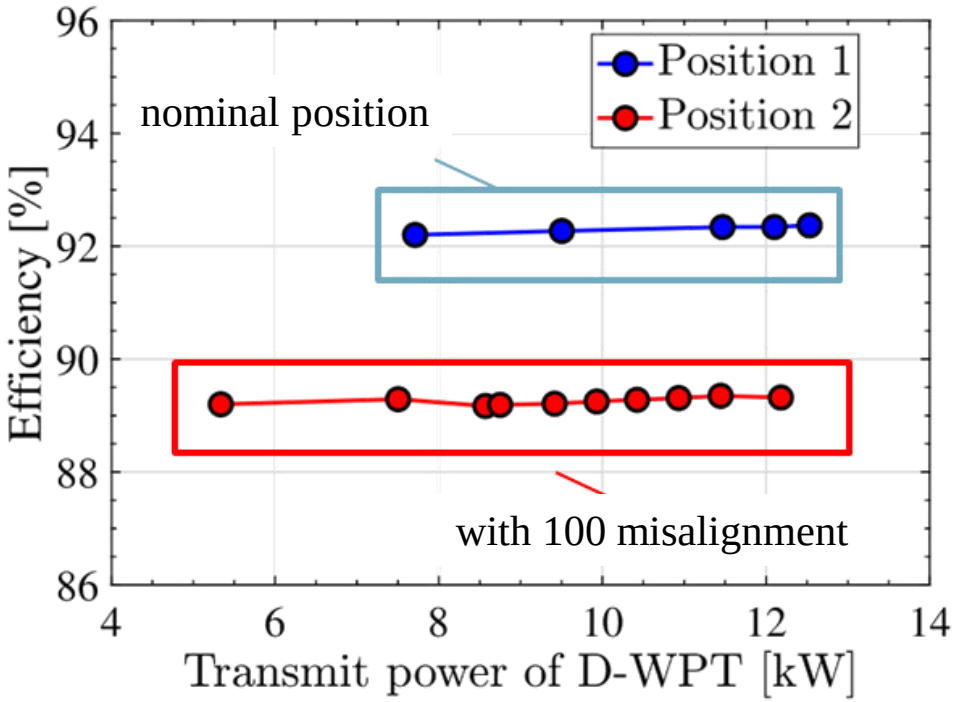
Achieved performance of WPT System

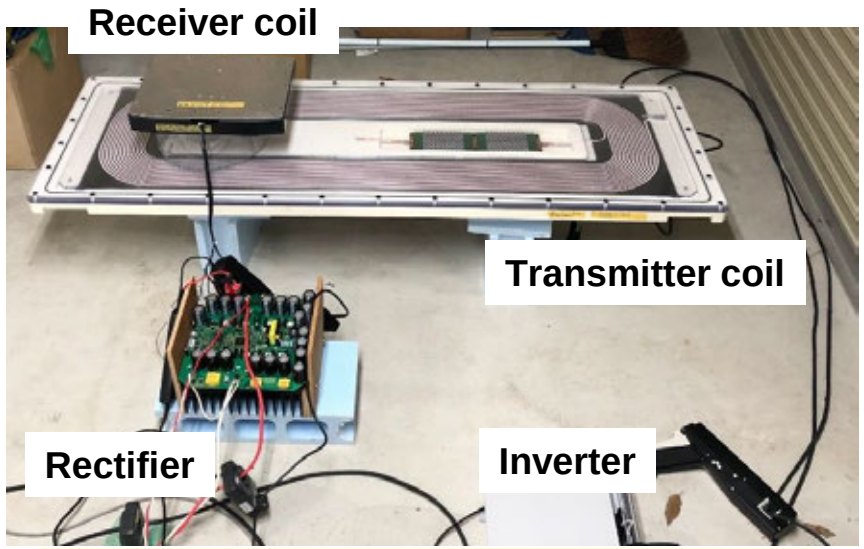
H. Fujimoto, et.al., EVS31&EVTeC2018

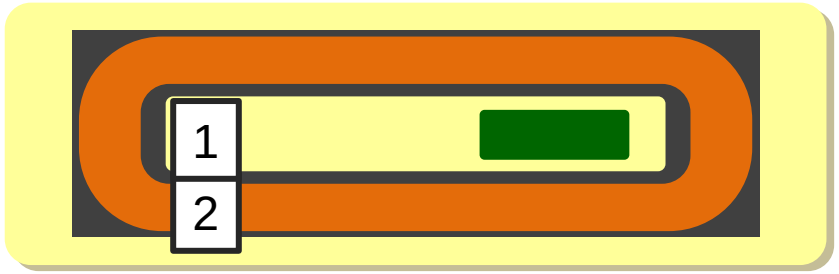
Charging Output : 12kW

Efficiency (DC to DC): 92.3% at nominal position

89% with 100mm misalignment







Third generation Wireless In-wheel Motor (WIWM-3)

1st Generation

WPT for driving

2nd Generation

DWPT with IWM

3rd Generation

Evolution of DWPT

all components in wheel

Infinity driving range

Open innovation

2015

2017

2019

Project Team

Project Management

The University of Tokyo(UT)

Motor

The University of Tokyo

NSK Ltd.

TOYO DENKI SEIZO K.K.

TDK Corporation

Rectifier

TOYO DENKI SEIZO K.K.

ROHM Co., Ltd.

Murata Manufacturing Co., Ltd.

Basic Research

The University of Tokyo

NSK Ltd.

Bridgestone Corporation

DENSO Corporation

ONO SOKKI CO.,LTD

TORAY Carbon Magic Corporation

CARMATE Corporation

Inverter

TOYO DENKI SEIZO K.K.

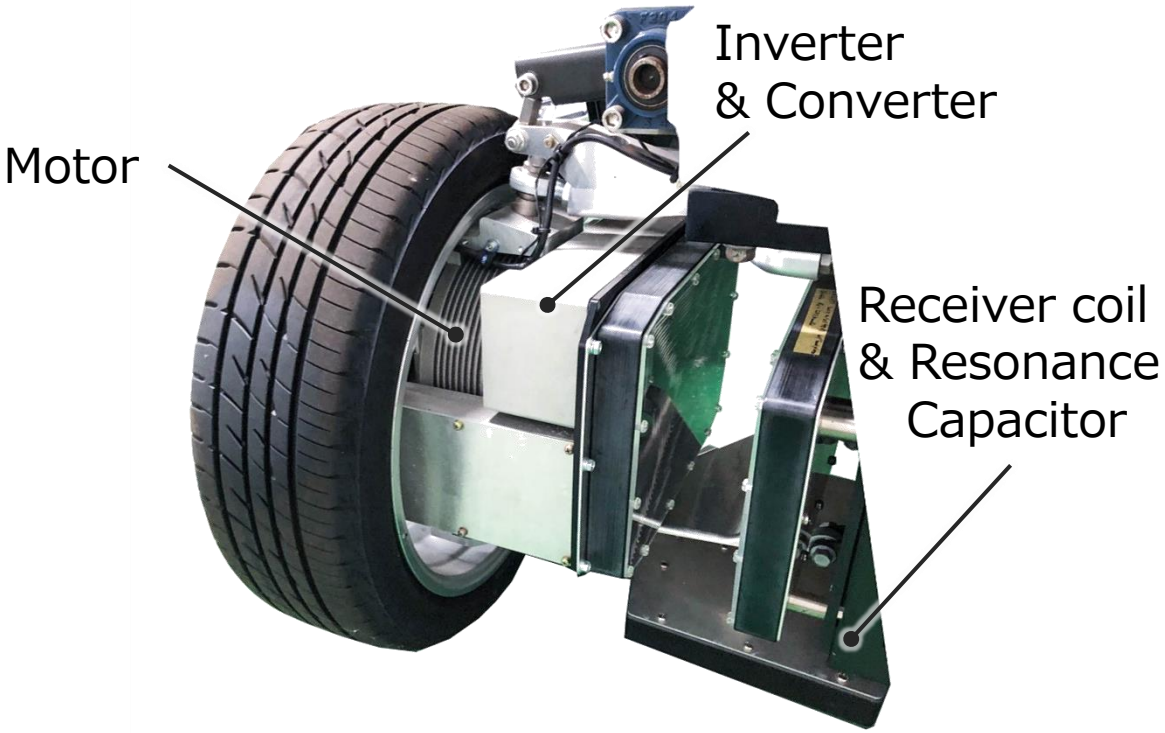
ROHM Co., Ltd.

T. RAD Co., Ltd.

Coils

The University of Tokyo

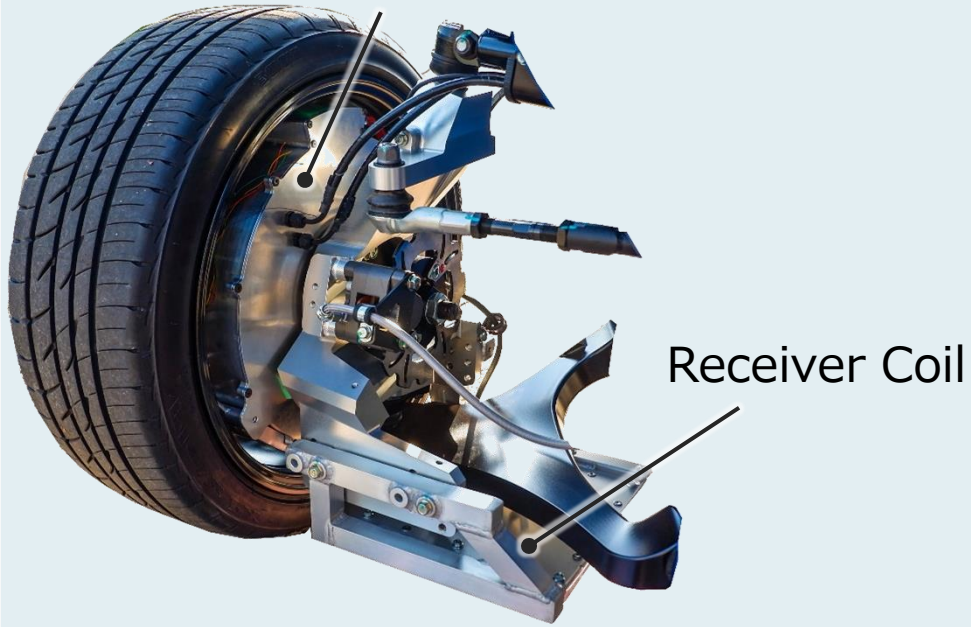
Structure of WIWM-3



WIWM-2

- ✓ 12kW WPT/wheel
- ✓ 12kW motor output/wheel(air cooling)
- ✓ All components are in unsprang area

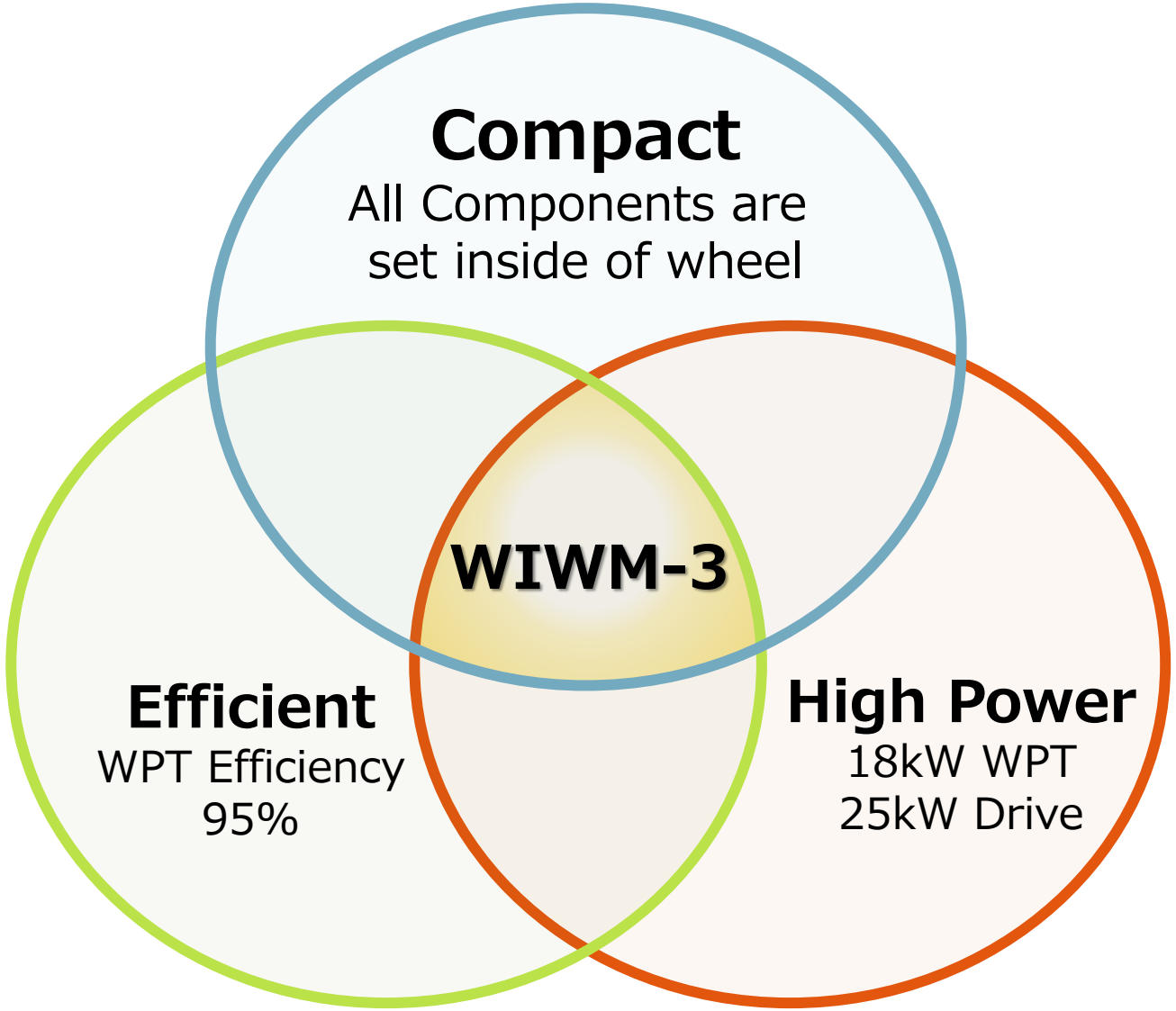
Motor＋Inverter＋Converter
＋Resonance Capacitor＋Cooling System



WIWM-3

- ✓ **18kW** WPT/wheel
- ✓ **25kW** motor output/wheel(water cooling)
- ✓ All components are in wheel

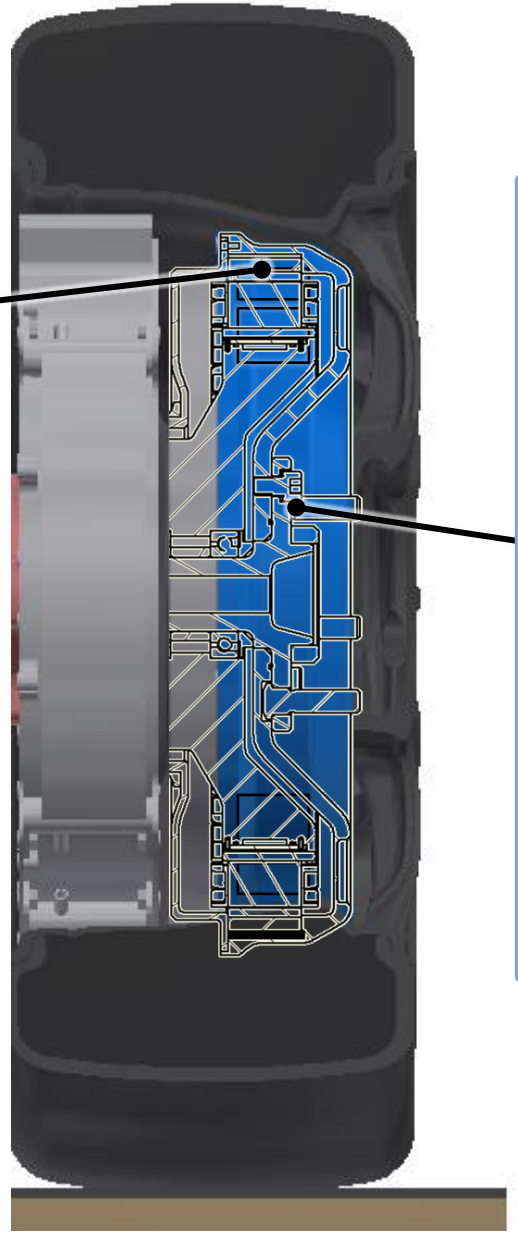
Requirements of WIWM-3



Feature of motor

Outer Rotor

- ✓ High torque output
- ✓ **Improved volumetric efficiency**



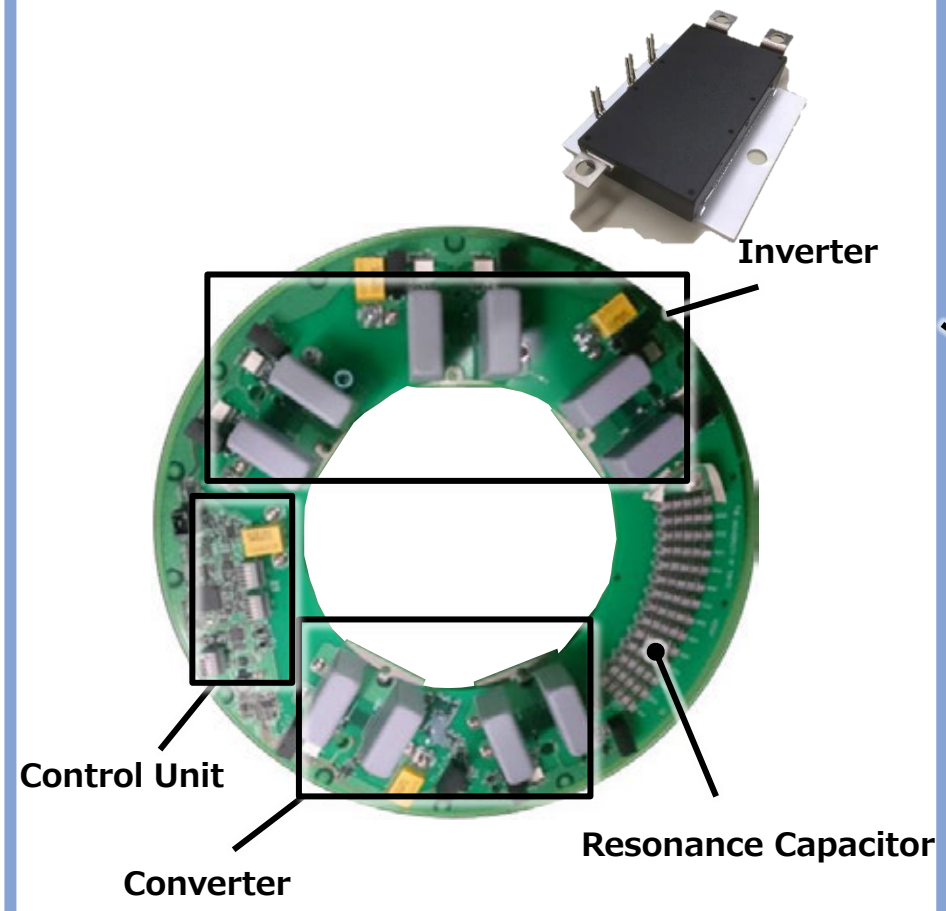
Direct Drive

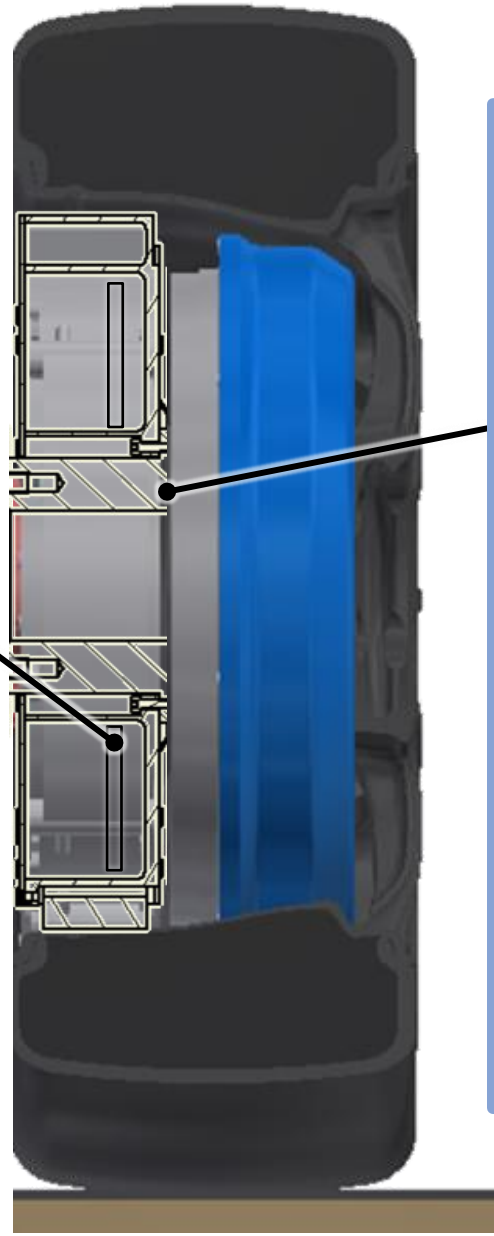
- ✓ **High efficiency** due to no gear
- ✓ **High response** due to no gear

Feature of power conversion unit

Circular Board

- ✓ **Super small SiC device**
- ✓ High efficiency active rectification

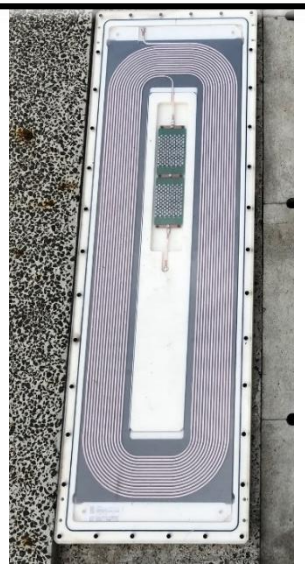




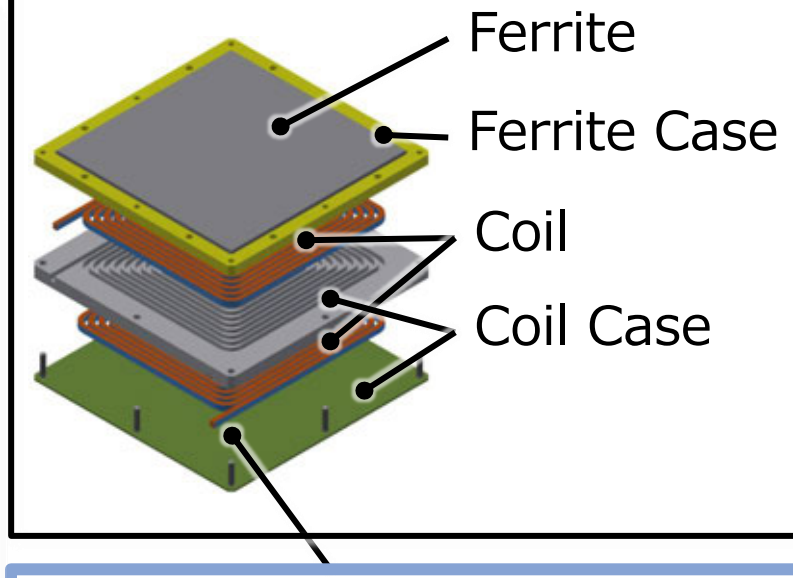
Electromechanical System

- ✓ High efficiency due to short wire
- ✓ Downsized by integrated cooling system

Evolution of Coils

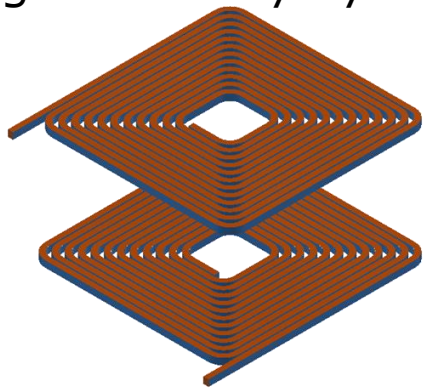
	WIWM-2	WIWM-3	Improvement
Receiver (vehicle side)	 254×387×37	 230×230×26.5	**Capacity 53%down**
Transmitter (road side)	 1500×490×45	 1086×318×45	**Capacity 61%down**
WPT Output	12kW	18kW	**50% up**
Efficiency (AC to AC, Theoretical)	96.5%	98.1%	**Loss 45% down**

Structure of Receiver



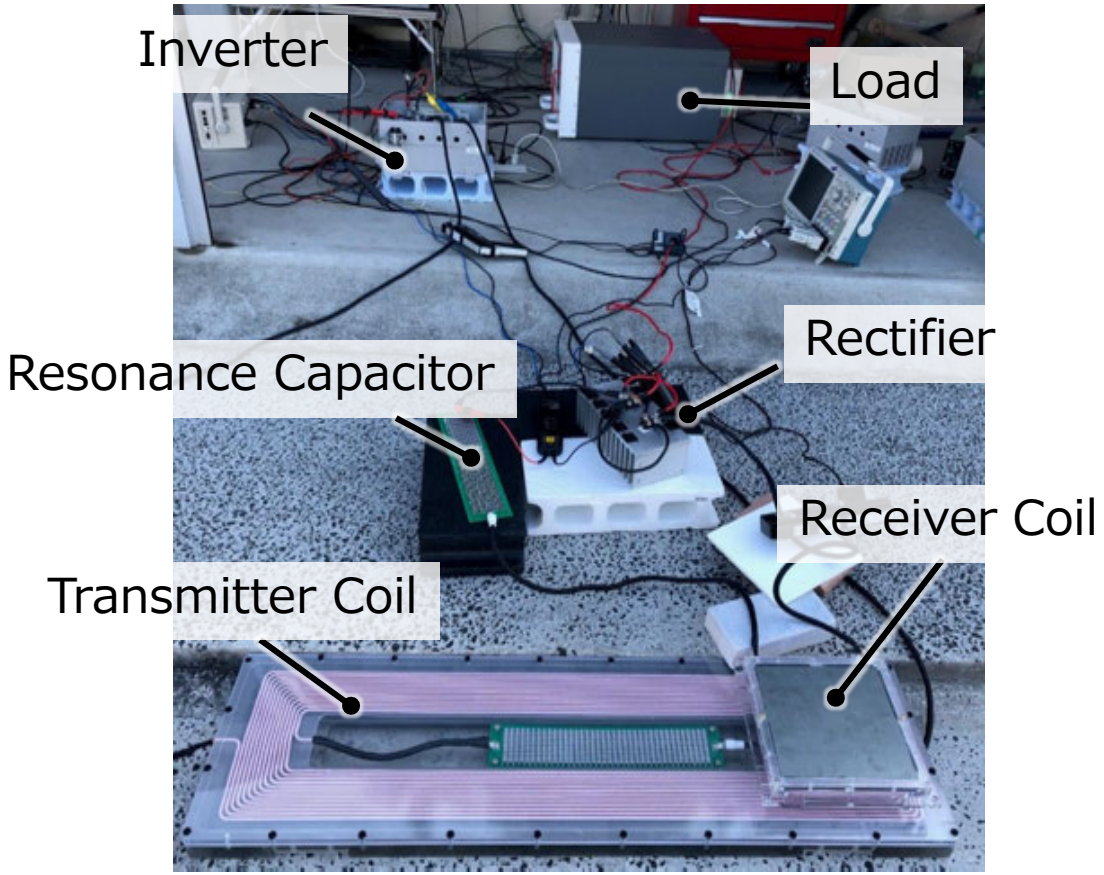
2 layers spiral coil

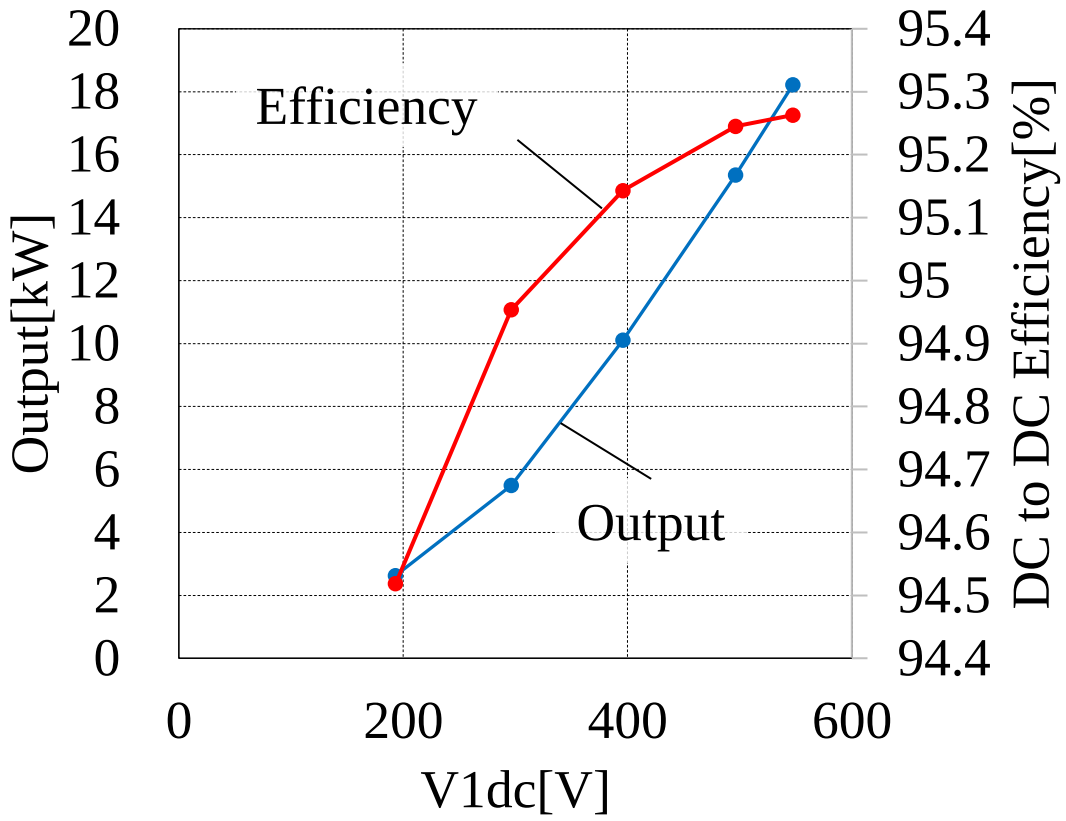
- ✓ Downsizing without inductance change
- ✓ High efficiency by 1wire



Achieved performance of WIWM-3

H. Fujimoto, et.al., WoW2020





18kW output with 95.2% DC to DC efficiency is achieved

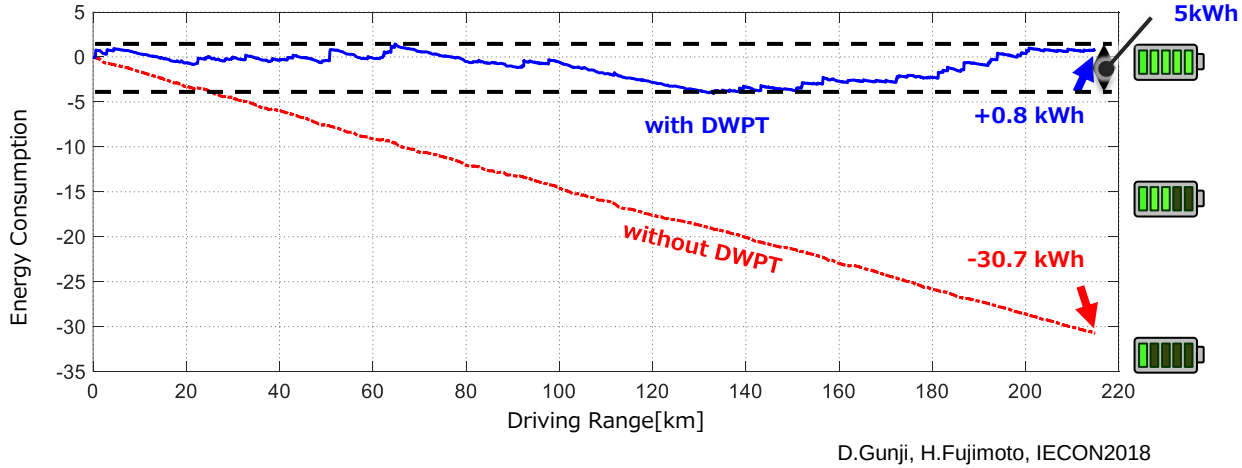
Vehicle test at the University of Tokyo

Rear View

Dynamic charging is achieved

Future society realized by DWPT

- **Smart City** will be demonstrated by 2025
  - 30m chargeable area in front of traffic signal
  - Battery SOC can be kept by DWPT
- Low vehicle cost by reducing the battery
- **Carbon neutral** will be achieved by DWPT



D.Gunji, H.Fujimoto, IECON2018

EVs will be more friendly for customers and the earth

Conclusion

We are developing novel driving system “WIWM”

WIWM-3 achieved high WPT power and efficiency

EVs will be more friendly for customers and the earth by DWPT