

<The 69th session of the EVE IWG>

Use of Simulations for Driving Ranges of BEVs

The-K Hotel Seoul, Seoul, South Korea

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National Institute of
Environmental Research



HANYANG UNIVERSITY

Driving Range Regulations for Battery Electric Vehicles in South Korea

- An Overall Process of Driving Range Certification for BEVs
 - Driving range certification process controlled by NIER

NIER: National Institute of Environmental Research
 MOE: Ministry Of Environment

OEMs who own certified testing facilities

<BEV Manufacturer>



✓ **Testing** BEVs driving range *by OEM*

Submitting Certification Documents

- OEM Self-test results
- BEVs information
- Test information

<MOE, NIER>



Utilize Simulation

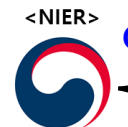
Qualified

Disqualified

<MOE, NIER>



✓ Issue a certificate



Qualified

✓ **Testing** BEVs driving range *by Agency*

Disqualified



✓ Issue a certificate



- ✓ Request supplement
- ✓ Reject certification

<Market>



OEMs who do not own appropriate testing facilities

<BEV Manufacturer>



Submitting Certification Documents

- BEVs information

<MOE, NIER>



✓ **Testing** BEVs driving range *by Agency*

<MOE, NIER>



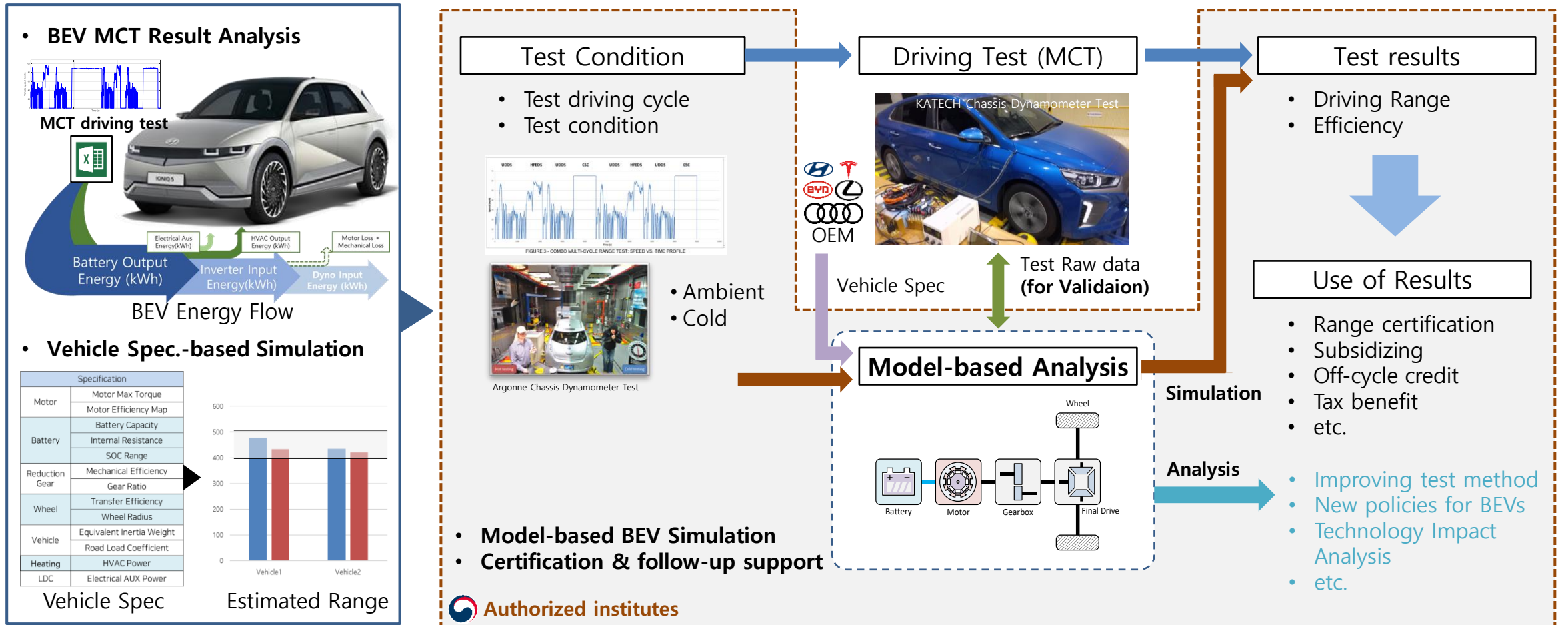
✓ Issue a certificate

<Market>



Driving Range Regulations for Battery Electric Vehicles in South Korea

- An Overall Process of Driving Range Certification for BEVs
 - Results validation based on simulation techniques for supporting the BEV Certification

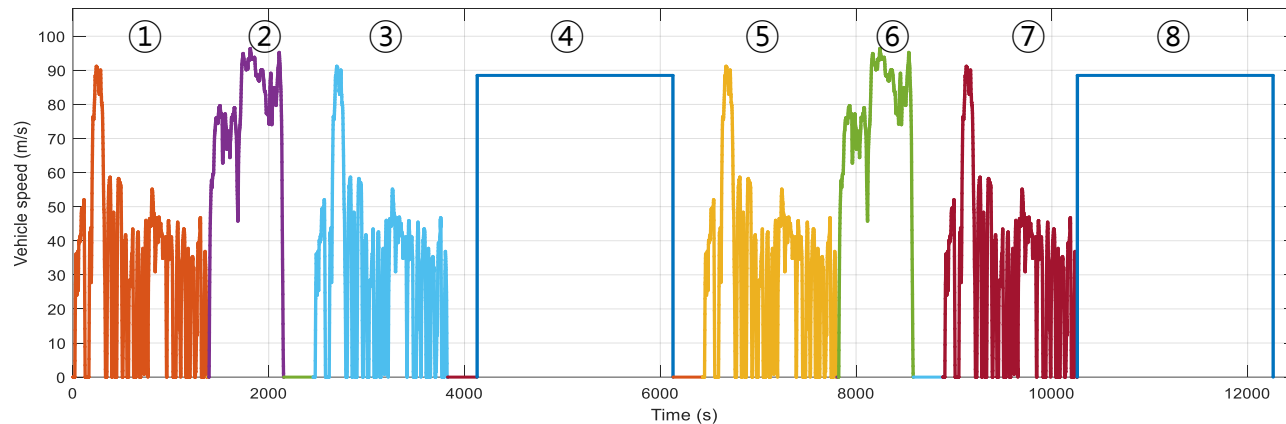


Driving Range Regulations for Battery Electric Vehicles in South Korea

- An Overall Process of Driving Range Certification for BEVs
 - MCT-based BEV testing certification for City/Highway/Combined driving range

Multi-Cycle Test Procedure for BEV Driving Range

▶ Ambient/Cold driving cycle (MCT : UDDS – Highway – UDDS – CSC, Repeat twice)



Driving Range Calculation

AC charging energy



DC discharge. energy

- > UDDS1 energy
- k_{UDDS1} (weight factor)
- > Energy consumption
- For city
- For highway

[별지 제13의2호서식]
전기자동차 1회충전 주행거리 시험내용보고서(UDDS 및 HEFEW모드)

시험자동차	시험 날짜	년	월	일
제조사	시험장소			
차대 번호				
공차 중량	kg	측정자		
도움부하중량(a, b, c)	kg	실험실 조건		
공차 주행 거리	km	기압		h _c
타이어 공기압	psi	습도		%
연료종류		배터리		시분표
전동기 제형		충전상태 시간		V
최대출력	kw/psm	시작 전압		V
정격전압	V	종료 전압		V
충전제형		용량		Ah
용량				
충전제형				

충전 자료 기록표

누적 교류 전력량(kWh)	누적 직류 전력량(kWh)	충전 소요시간(시간)

주행 자료 기록표 (상온시험)

순서	도시	주행거리 (km)	누적주행거리 (km)	시험종료 후 양전지 직류 소비량(kWh)	시험종료 후 직류 직류 소비량(kWh)	비고
1						
2						
3						
...						

시험종료 후 양전지 충전시각이 요구되는 직류 및 교류 전력량(kWh)

1						
2						
3						
...						

시험종료 후 양전지 충전시각이 요구되는 직류 및 교류 전력량(kWh)

Certification Documents

Mode	UDDS1	HWFET1	UDDS2	CSCm	UDDS3	HWFET2	UDDS4	CSCe
Range
Energy

Driving Range(km)

Usable Battery Energy [kWh]

Each cycle DC discharge energy consump. [kWh/km]

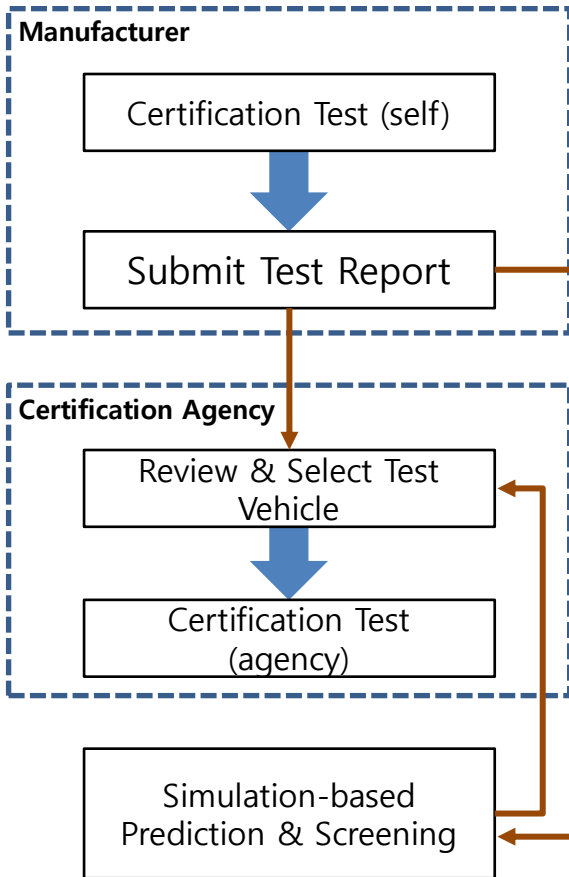
Energy Consumption of City and Highway
→ **Driving Range of City and Highway**

	EC_city	EC_highway	FE_city	FE_highway	FE_combined	Range_city	Range_highway	Range_combined
Ordinary	0.2554	0.3757	2.3184	1.5764	1.9132	152.7317	103.8506	130.7352
Cold	0.3346	0.4376	2.6238	2.0067	2.3049	166.1319	127.0590	148.5491

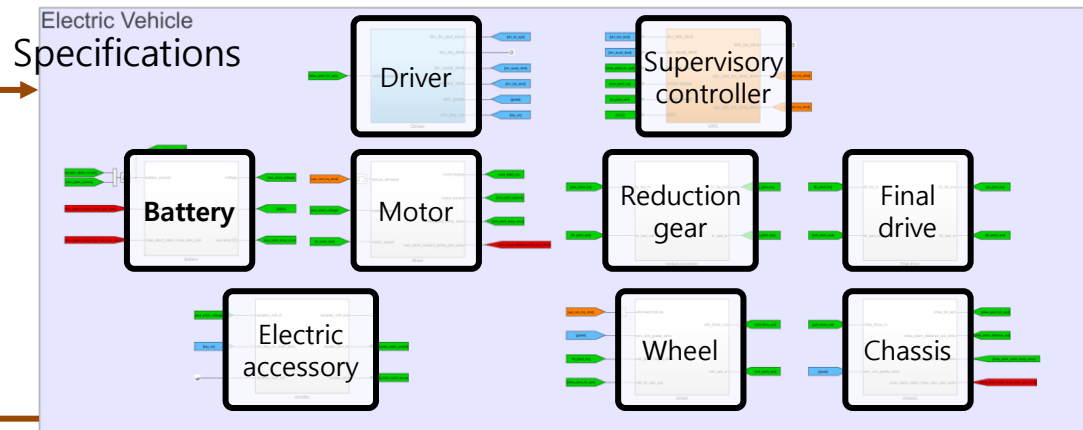
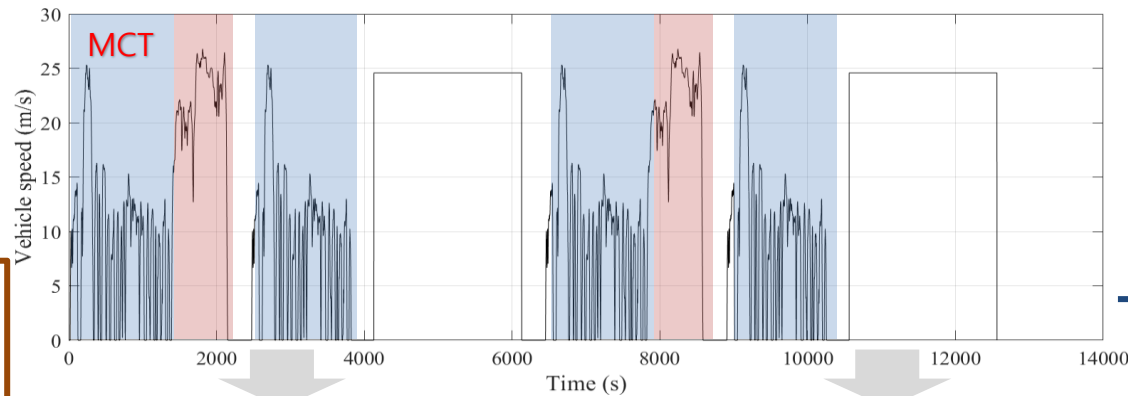
Simulation Tool Development for Driving Range Evaluations

- A Simulation Tool for Driving Range Analysis of BEVs
 - Overview of BEVs driving range simulation process

Certification Process



Driving Range Test Simulation



• MCT Simulation (SAE J1634) → UDDS + HWFET → Driving Range

App Development & Deployment



Simulation Tool Development for Driving Range Evaluations

- Model Validation by Analyzing Results Obtained by Real-world Driving Tests
 - Develop and validate models based on MCT time-series test data

Specifications



Hyundai – IONIQ5 MY21 RWD

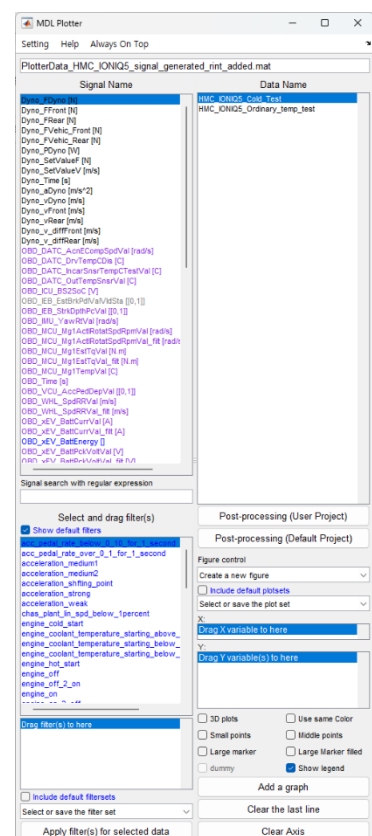
Battery	Lithium-ion Polymer 111.2 Ah, 72.6 kWh 180 cells, 653 V
Motor	PMSM 350 Nm, 168 kW
AER	300 miles (482 km)
Gear	10.65
FE (EPA)	132/98 MPGe (city/hwy)
0-60mph	7.4 s

Test Cycle

UDDS, HWFET, MCT

Parameter Estimation

Test data analysis → Parameter estimation process using chassis dynamometer data



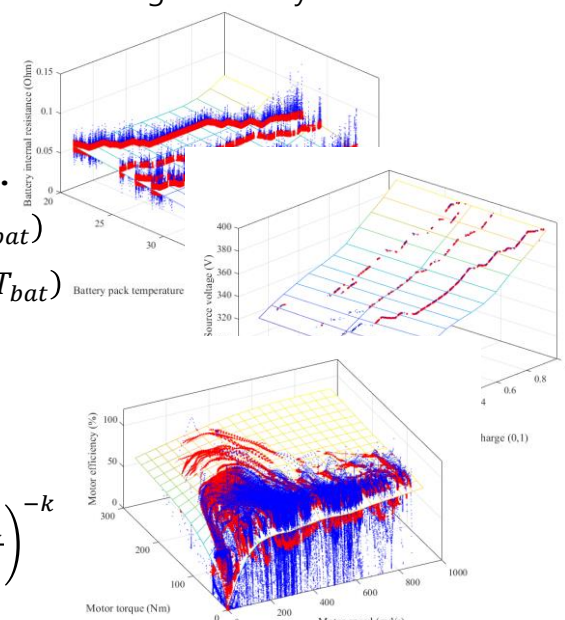
Battery param.

$$R_i = f(SOC, T_{bat})$$

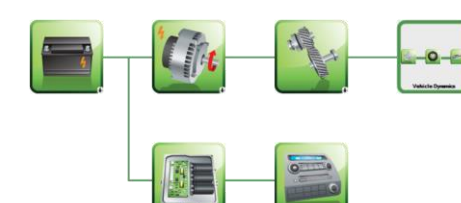
$$V_{OC} = f(SOC, T_{bat})$$

Motor param.

$$\eta_{mot} = \left(\frac{P_{mech}}{P_{elec}} \right)^{-k}$$

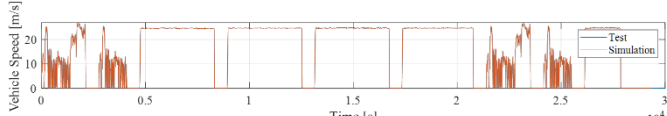


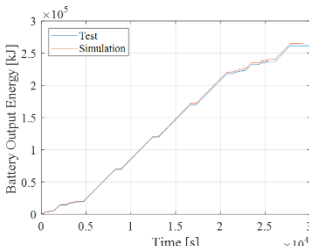
Modeling

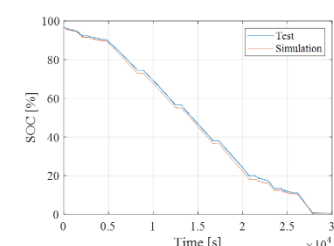


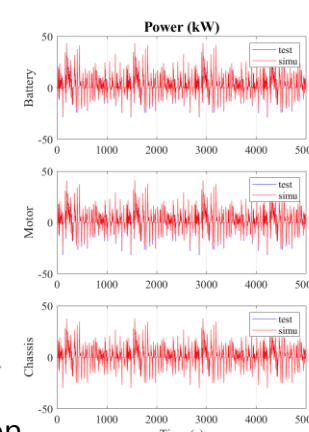
Validation

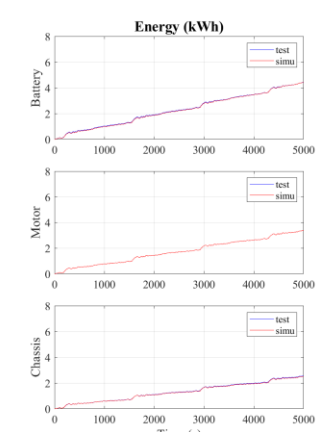
Model Validation











Final error of $E_{bat} = 0.36\%$ (90W)

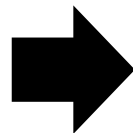
Simulation Tool Development for Driving Range Evaluations

- Comparative Study: Results of Driving Range By Tests vs. Simulations
 - The development is in-progress by considering additional impacts on the driving ranges.

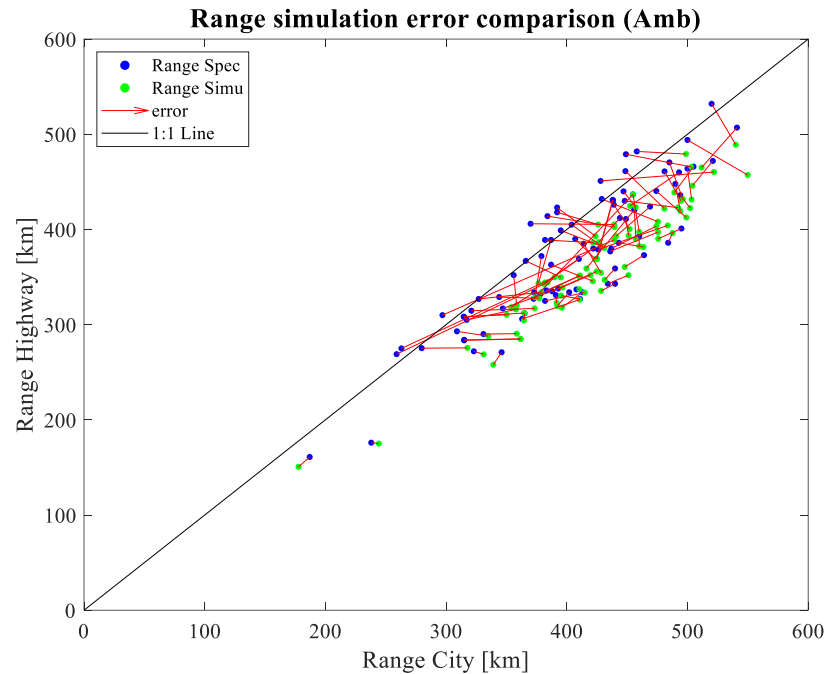
BEVs Specifications

BEVs Specifications provided by the manufacturer

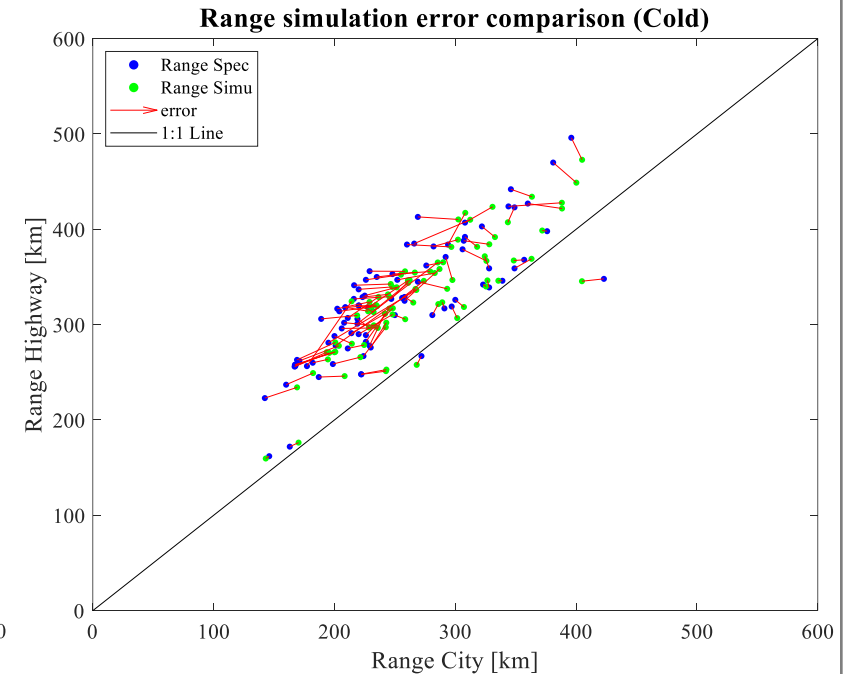
Enter BEV specifications data into the simulation



Ambient MCT Simulation Result



Cold MCT Simulation Result



The simulation results are considering to be used in the screening process to selectively conduct the driving tests by NIER.

Thank you!

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