<The 69th session of the EVE IWG>

Use of Simulations for Driving Ranges of BEVs

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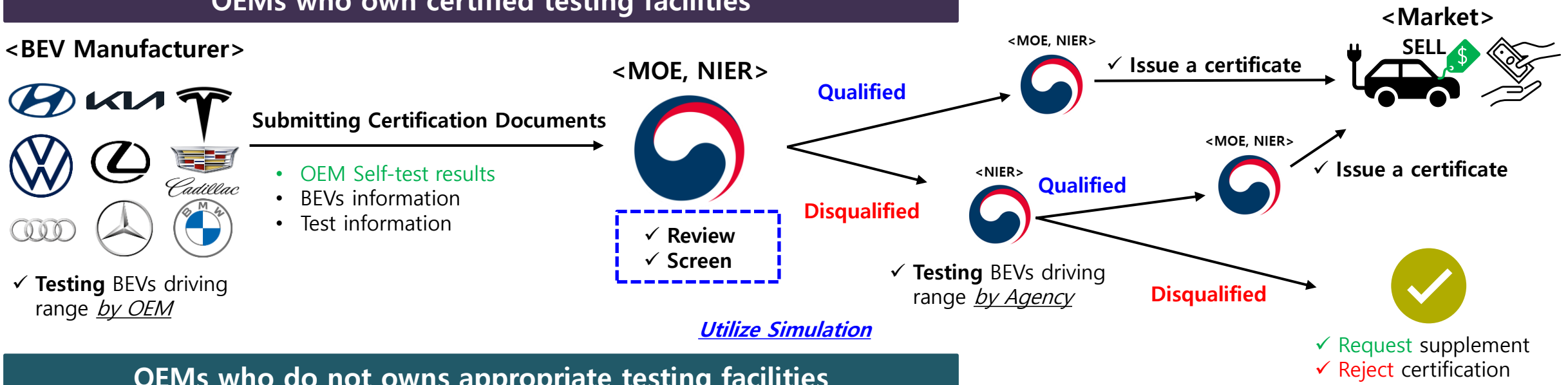
Driving Range Regulations for Battery Electric Vehicles in South Korea

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

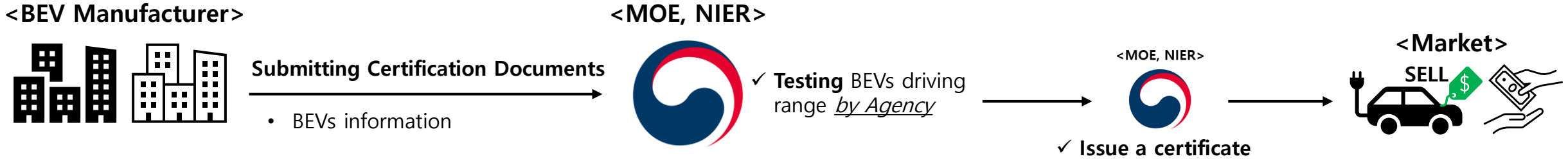
NIER: National Institute of Environmental Research

MOE: Ministry Of Environment

OEMs who own certified testing facilities

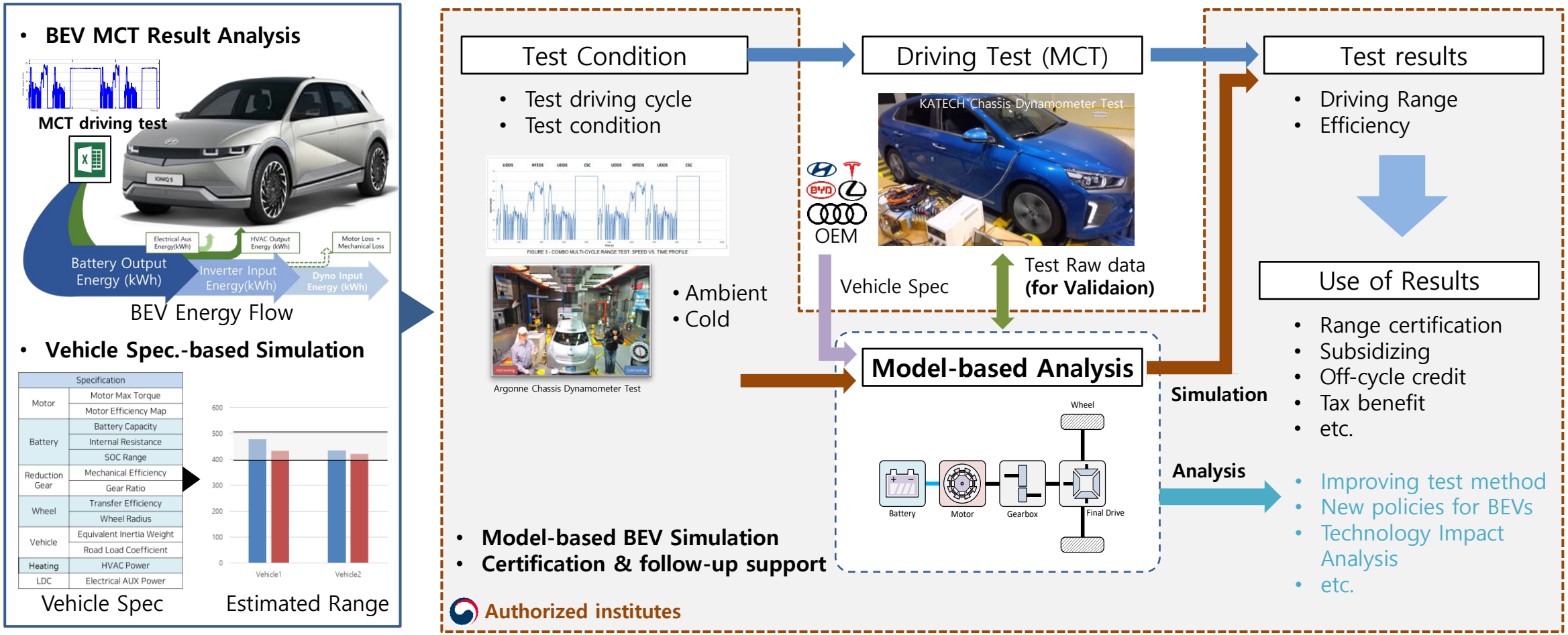


OEMs who do not owns appropriate testing facilities



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

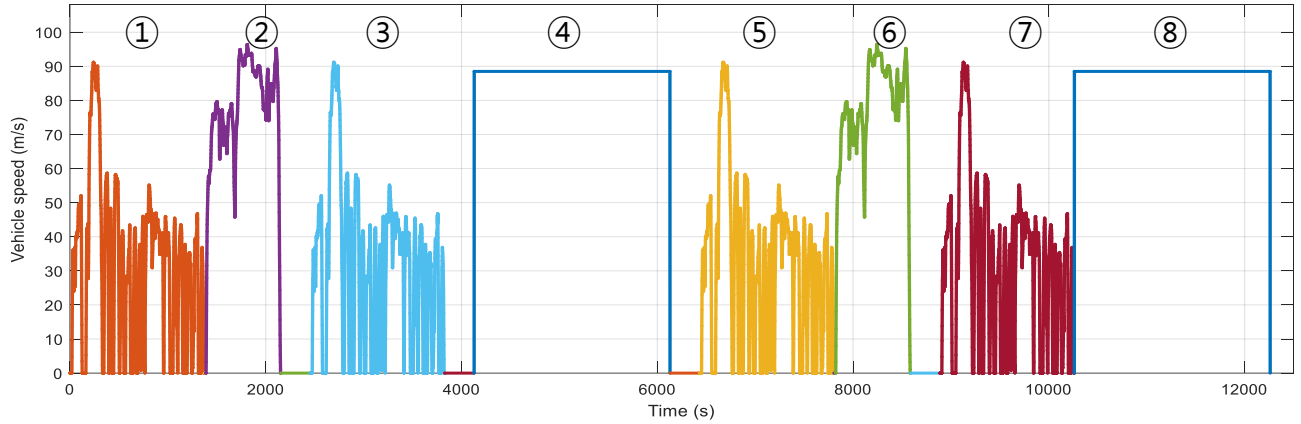


Driving Range Regulations for Battery Electric Vehicles in South Korea

- 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)



Mode	UDDS1	HWFET1	UDDS2	CSCm	UDDS3	HWFET2	UDDS4	CSCe
Range	…	…	…	…	…	…	…	…
Energy	…	…	…	…	…	…	…	…

	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

Driving Range Calculation

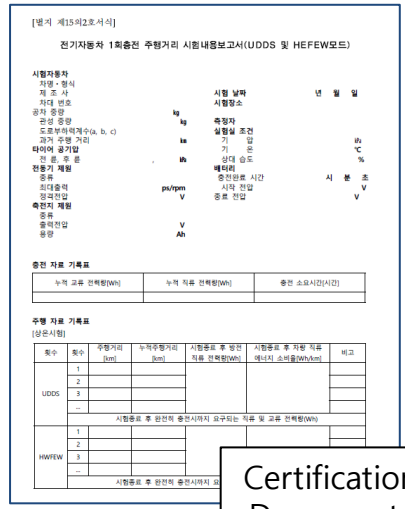
AC charging energy

+

DC discharge. energy

> UDDS1 energy
→ k_{UDDS1}(weight factor)

> Energy consumption
→ For city
→ For highway



Certification Documents

Driving Range(km)

$$\frac{Usable\ Battery\ Energy\ [kWh]}{Each\ cycle\ DC\ discharge\ energy\ consump.\ [kWh/km]}$$

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

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** | **App Development & Deployment**

Manufacturer

Certification Test (self)

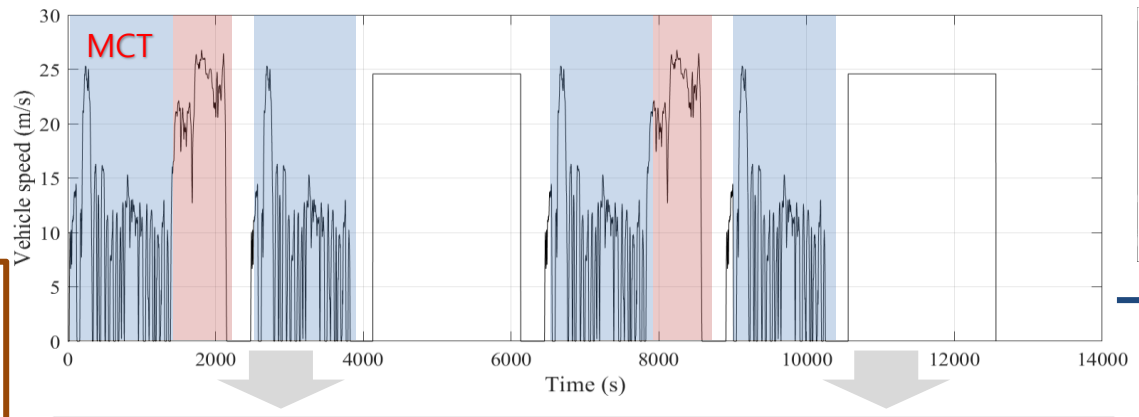
Submit Test Report

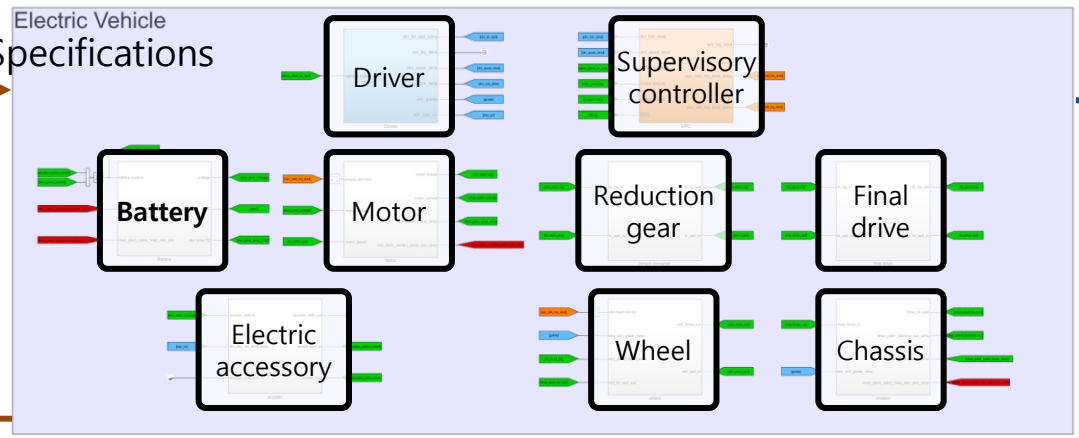
Certification Agency

Review & Select Test Vehicle

Certification Test (agency)

Simulation-based Prediction & Screening





- MCT Simulation (SAE J1634) ➔ UDDS + HWFET ➔ Driving Range

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

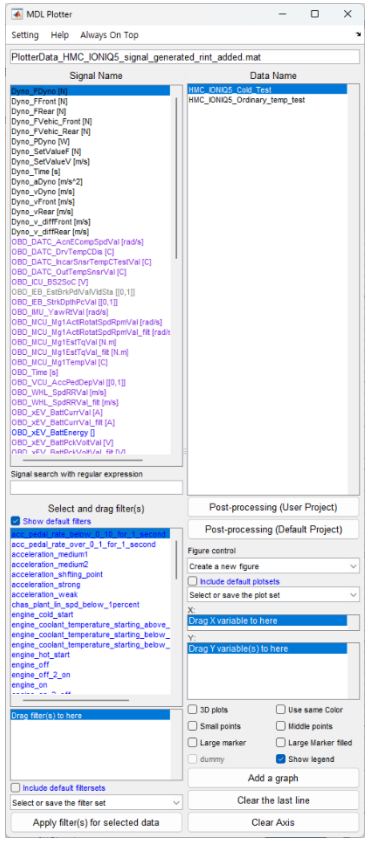
Battery	Lithium-ion Polymer 111.2 Ah, 72.6 kWh 180 cells, 653 V
Motor	PMSM 350 Nm, 168 kW
AER	300 miles (482 km)
Gear	10.65
FE (EPA)	132/98 MPGe (city/hwy)
0-60mph	7.4 s

Test Cycle

UDDS, HWFET, MCT

Parameter Estimation

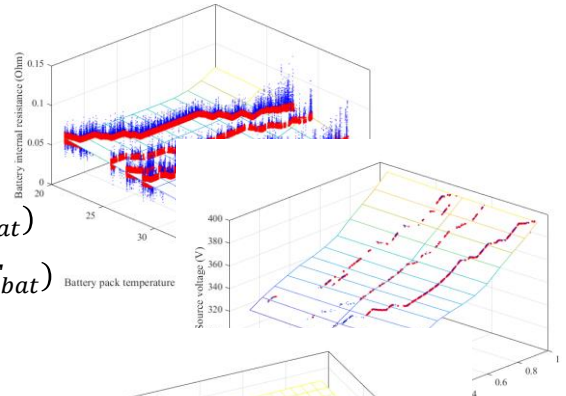
Test data analysis ➔ Parameter estimation process using chassis dynamometer data



Battery param.

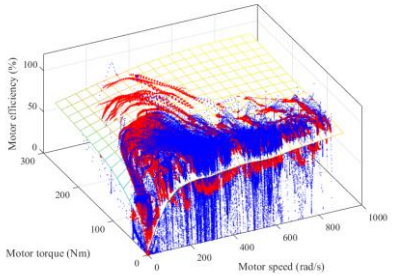
$R_i = f(SOC, T_{bat})$

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



Motor param.

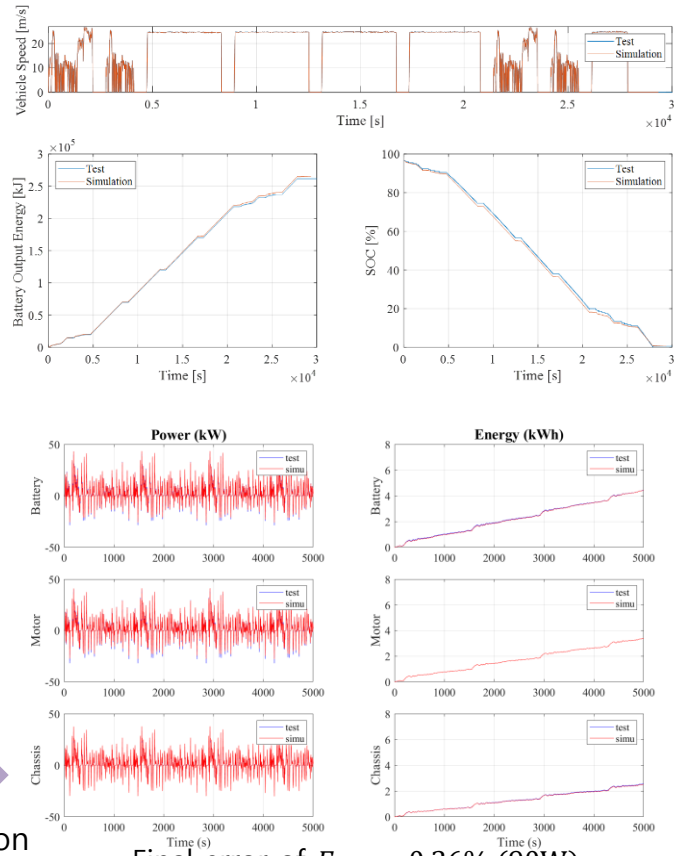
$$\eta_{mot} = \left(\frac{P_{mech}}{P_{elec}}\right)^{-k}$$



Modeling

Validation

Model Validation

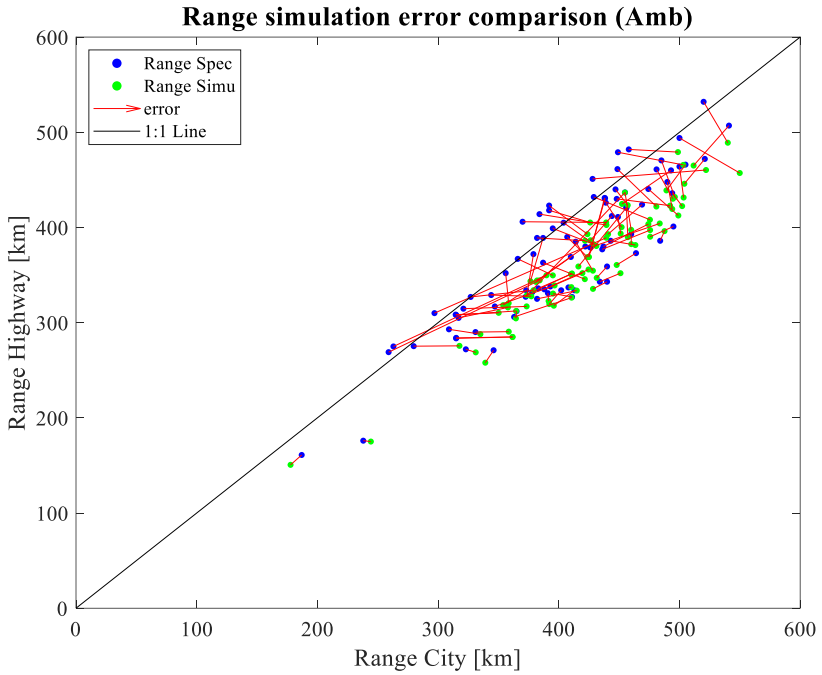


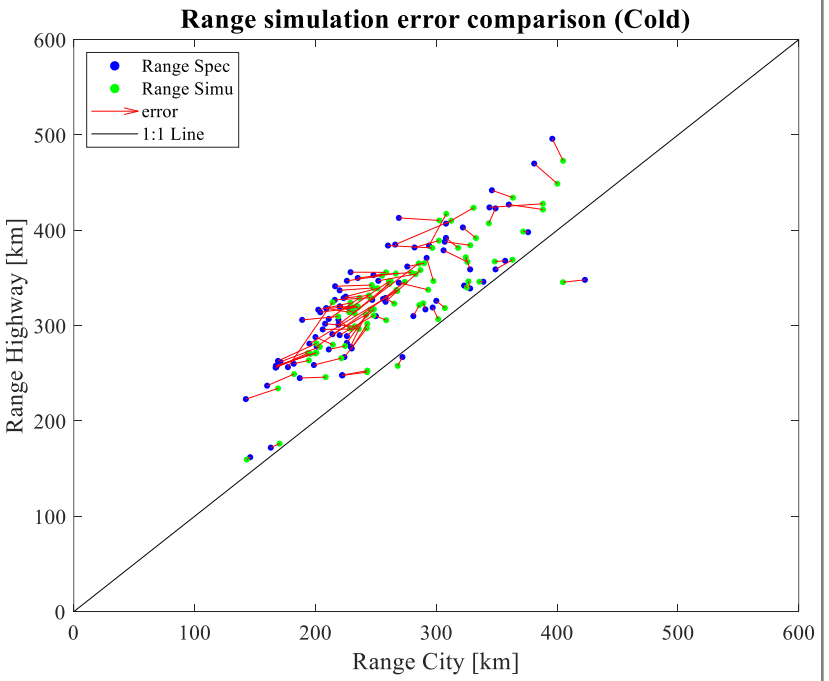
Final error of E_{bat} = 0.36% (90W)

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	Ambient MCT Simulation Result	Cold MCT Simulation Result





Enter BEV specifications data into the simulation

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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