講演番号	048

Battery development for third-generation new EV

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KEY WORDS: **EV and HV systems, battery technology** [A3]

Electric vehicles (EVs) are being adopted worldwide to reduce environmental impact and realize sustainable mobility; since launching the world' s first mass-produced EV in 2010, Nissan has sold approximately 700,000 EVs globally over 15 years, and the third-generation model was developed by leveraging accumulated operational data, user behavior insights, and advances in thermal and battery management to address persistent user concerns about limited driving range and extended fast-charging times. Recognizing that range and charging performance are not determined solely by battery capacity but by a combination of capacity, cost, and thermal management, the development strategy emphasized three integrated approaches: capacity optimization informed by big-data analysis, an Intelligent Route Planner (IRP) that predicts state of charge (SOC) and charging needs with high accuracy, and an Integrated Thermal Management System that recovers and reallocates waste heat to maximize charging acceptance and reduce auxiliary heating energy.

Capacity optimization used extensive market-collected data−covering driving distances, charging frequency, battery temperatures, and usage patterns since the first model−to identify the practical battery size that meets customer needs while avoiding unnecessary weight and cost; in the Japanese market, weekend distance distributions showed that internal combustion engine (ICE) vehicle travel aligned with a 66 kWh EV, but analysis of annual maximum-distance distributions and the observed tendency of EV users to avoid long trips without en-route charging led to selecting a slightly reduced optimal capacity of 55 kWh for this market, striking a balance between usable range, vehicle mass, and affordability.

To mitigate the increased charging frequency that can accompany capacity reduction, the IRP was developed to integrate route-specific driving load information and charger output data from the in-vehicle navigation system with vehicle-control-unit computations, enabling high-precision prediction of SOC at charging stops and at final arrival; because battery internal resistance and charge acceptance are highly temperature-dependent, the IRP incorporates comprehensive battery-temperature models derived from diverse vehicle and cooling-system configurations across markets to refine SOC and charging-time estimations, which reduced arrival-SOC estimation errors to approximately 2%.

Complementing these capabilities, the Integrated Thermal Management System physically links HVAC, the e-powertrain (motor and inverter), and the battery via a coolant loop to recover heat generated during driving and charging and reuse it for cabin heating or for preconditioning the battery prior to fast charging, thereby improving overall thermal energy efficiency and maximizing charge acceptance when rapid charging is needed in low-temperature environments; this system is controlled in coordination with IRP predictions so that the battery is warmed to an optimal temperature window at prescribed charging points without using excessive additional energy, avoiding over-heating while ensuring maximal energy uptake during the charging session.

These three elements were validated both individually and together: big-data-driven capacity selection demonstrated that a 55 kWh battery delivers practical everyday range for the target market while limiting cost and mass, IRP testing showed consistent SOC and charging-time prediction accuracy by leveraging battery-temperature-aware models, and thermal integration measurements confirmed effective recovery of battery heat for cabin warmth and significant reductions in supplemental pre−heating energy. In Fig.1, 1,000 km cold-weather route that followed IRP-proposed stops and charging timing−including two fast-charge locations−was executed using the optimized battery capacity and the integrated thermal controls; results showed that IRP' s SOC predictions at each charging stop and at final arrival remained within 5% error across the entire trip, and that preconditioning coordinated by the thermal management system maintained the battery in its charge-acceptance optimum while suppressing additional heating energy, thereby maximizing delivered charge and minimizing auxiliary energy consumption.

By combining capacity optimization, predictive route and charging planning, and coordinated thermal energy recovery and control, the third-generation EV demonstrates that it is possible to reconcile the traditional trade-offs among performance, cost, and convenience: the integrated approach concurrently secures reliable long-distance capability, robust charging performance in cold conditions, and improved energy efficiency, offering a practical and economical EV experience for users without resorting to oversized batteries.

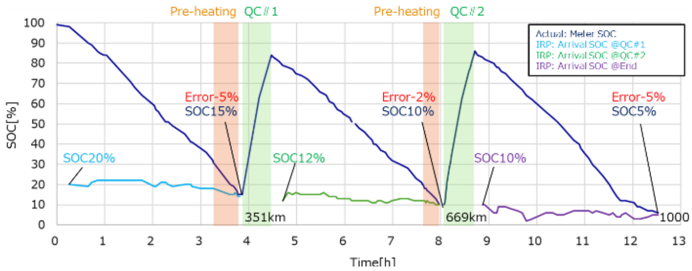

Fig.1 Validation of IRP Accuracy and Pre-heating of 1000km