Performance Requirements

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PerformanceRequirements

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Description:

Performance Requirements: Self-Charging Electric Vehicle (SCEV) Project

These performance requirements outline the expected performance characteristics of the Self-Charging Electric Vehicle (SCEV) system, encompassing both the hardware and software components. They are categorized for clarity and measurability.

1. Performance Goals:

- **Maximize Energy Harvesting:** The combined energy harvesting system (solar, kinetic, thermal) should achieve a minimum average energy generation of X kWh per 100 km driven under average real-world conditions (defined by a weighted average of various geographical locations and weather patterns). This will be benchmarked against a baseline of a standard EV of similar size and weight.

- **Extend Effective Range:** The harvested energy should extend the vehicle's effective range by a minimum of Y% compared to a comparable standard EV under similar driving conditions.
- **Minimize Charging Time:** The time required for the vehicle to fully charge using only harvested energy should be less than Z hours under optimal conditions (e.g., continuous strong sunlight and smooth driving).
- **Real-time Energy Management:** The AI-powered Energy Management Unit (EMU) should respond to changes in energy generation and vehicle demand within T milliseconds to optimize energy flow.

2. Response Time Requirements:

- **EMU Response Time:** The EMU must respond to sensor data and adjust energy distribution within T milliseconds (T will be defined based on system simulations in Milestone 1).
- **Dashboard Updates:** The driver dashboard should update the energy generation display at least every U seconds to provide real-time feedback. (U will be determined based on user experience testing).

3. Throughput Expectations:

- **Data Processing Throughput:** The EMU should process sensor data from all sources (solar panels, suspension system, TEG units) at a rate of at least V data points per second without performance degradation. (V will be determined based on the number and data rate of sensors).
- **Energy Conversion Efficiency:** Each energy harvesting system should exhibit a minimum conversion efficiency of W% (W will be specific to each system: solar, kinetic, thermal).

4. Scalability Requirements:

- **Future Technology Integration:** The system architecture should accommodate the integration of future energy harvesting technologies without significant redesign or performance impact.
- **Data Volume Handling:** The EMU should be able to handle an increasing volume of sensor data as more sophisticated sensors are integrated. Performance should remain acceptable even with a X% increase in data volume.

5. Resource Utilization:

- **Power Consumption:** The energy harvesting and management system itself should consume a minimal amount of power, less than P% of the vehicle's total energy consumption during operation.
- **Computational Resources:** The EMU’s computational requirements should be optimized to minimize the strain on the vehicle's onboard processing unit.

6. Load Handling:

- **Peak Load:** The system should handle peak energy demands (e.g., acceleration) without significant performance degradation.
- **Sustained Load:** The system should maintain consistent performance under sustained high loads (e.g., highway driving).

7. Caching Strategy:

- **Sensor Data Caching:** Implement a caching mechanism for frequently accessed sensor data to reduce latency and improve response time. The cache size and eviction policy will be determined based on performance testing.
- **Prediction Model Caching:** Cache pre-computed energy generation predictions based on location and weather data to reduce computational overhead.

8. Performance Metrics:

- **Energy Generation (kWh/100km):** Measured under various driving conditions.
- **Range Extension (%):** Compared to a baseline EV.

- **EMU Response Time (ms):** Measured under various load conditions.
- **Data Processing Latency (ms):** Measured for each sensor type.
- **System Power Consumption (W):** Measured during different driving scenarios.
- **Conversion Efficiency (%):** Measured for each energy harvesting technology.
- **CPU Utilization (%):** Measured for the EMU and other relevant components.
- **Memory Usage (MB):** Measured for the EMU and other relevant components.

9. Monitoring Requirements:

- **Real-time Monitoring:** Continuous monitoring of key performance metrics (CPU usage, memory usage, energy generation, response times) via a dedicated monitoring dashboard.
- **Logging:** Detailed logging of all system events, errors, and performance data for analysis and troubleshooting.
- **Alerting:** Automated alerts for critical performance issues (e.g., significant drop in energy generation, high CPU usage, system errors).

10. Performance Testing Plan:

- **Unit Testing:** Thorough testing of individual components (solar panels, suspension system, TEG units, EMU modules).
- **Integration Testing:** Testing the interaction between different components.
- **System Testing:** Testing the entire system under various real-world conditions (different weather conditions, road types, driving styles).
- **Load Testing:** Simulating various load conditions to assess system performance under stress.
- **Endurance Testing:** Long-term testing to evaluate the system’s reliability and performance over time. This will involve simulated driving cycles and environmental conditions.

Baseline Requirements: Baseline performance will be established by comparing the SCEV system to a commercially available EV of similar size, weight, and battery capacity. Specific baseline metrics will be determined during Milestone 1.

Scalability Considerations: The system architecture should be designed to accommodate future improvements in energy harvesting technologies and increased data volumes from more sophisticated sensors.

Resource Constraints: Resource constraints (computational power, memory, power consumption) will be considered throughout the design and development process. Trade-offs between performance and resource utilization will be carefully evaluated.
